

A STUDY OF AIM AND STRATEGY OF STABILITY CONTROL IN QUASISTATIONARY STANDING

Haldo Östlund
Editor

1979

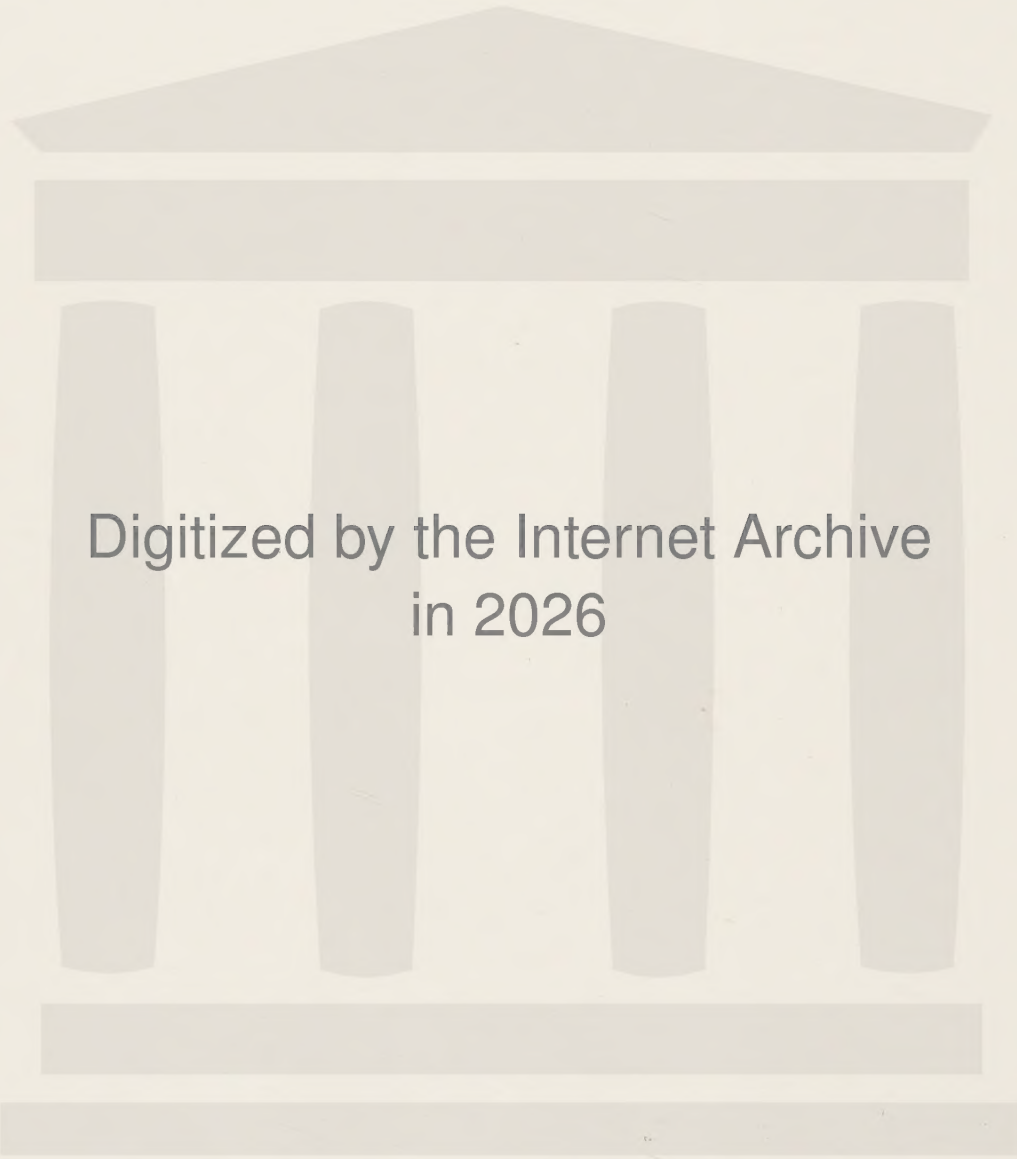


UNIVERSITY OF LUND
LUND, SWEDEN

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IN QUASISTATIONARY STANDING

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GENERAL INTRODUCTION

Since a long time it has been known that Man never stands perfectly immobile (29, 38). In spontaneous standing there is a constant slow shift of body attitude (68) possibly for maintenance of physiological integrity. Continuous oscillations of small magnitude and dominantly low velocity are present in quasistationary standing (= almost or seemingly immobile upright posture, synonym used, "static" standing) performed in accordance with explicit requirements urged by a test instruction (47, 70, 38). Although the body is seemingly rigid, it is nevertheless to a small extent flexible (70). The small and intermittent signs of muscular activity, found in EMG-studies (27, 28, 22, 52, 42, 59, 49), and the low consumption of energy (35) in "static" standing suggest that the postural oscillations are to a great extent of a passive nature. It is supposed that the human body lacks inherent stability, which is a cause of the body movements. This state of things makes the action of a dynamic control system necessary to secure stability of the configuration, position and orientation of the body (32, 55, 41, 50, 51, 34).

The standing person — thus including a presumed control system — is supposed to be able to choose a position of stable equilibrium, in the neighbourhood of which small oscillations could go on without disturbance of the stability of the posture, and necessitate a change of the strategy of balance. Any quasistationary state cannot probably exist for more than a short period of time.

Slight and intermittently acting muscular forces would then sufficiently restrict tendencies towards increased postural oscillations.

In preliminary studies the oscillations of the centre of mass were found to be stationary during an examination period of four minutes (56). The difference between the standard deviation of the first two and the second two minutes of a time series of four minutes duration was insignificantly different from zero in 25 individuals.

Presuming the configuration of the human body during "static" standing to be virtually rigid would mean that the postural movements are sufficiently described by variations of the position of the vertex of the head or some other part of the body (38, 47, 18) or by variations of the position of the mass centre (55, 70, 34, 4, 1). Measurements of the degree of variation of such variables have been proposed as relevant estimates of balance (18, 30, 47, 25). This may, however, be questioned since postural movements may be extensive although the balance is sufficient. Referring to the assumption made above concerning a control system, the examination of the dynamics of the postural movements in "static" standing is thus more illustrative of the process of postural control i.e. balance (55, 21, 69).

Biological systems are mostly examined by subjective methods especially when complex behavior is concerned. In clinical work the adaptive potential of subjective methods, with regard to the procedure in general, recognition, selection and

recording of the relevant phenomena and the process of decision, make them superior to wellcontrolled and strictly defined but also somewhat rigid and stereotyped objective procedures. Reasonably it is impossible to apply an objective procedure under too general conditions. Thus the aim of biological system is known only from its expressive behaviour, meaning that a certain degree of regularity of the behaviour is required for the interpretation of the observations. It is, however, possible to imagine situations, in which the experimental bias attached to subjective estimations motivates objective measurements.

In the present paper a method for estimation of the magnitude and dynamics of the oscillations of the centre of mass during quasistationary standing is described. Matters of stationarity, regularity and of the meaning of the information conveyed are discussed.

In this study the following assumptions were made, which, to a certain extent, are confirmed by experimental results:

1. The postural movements in "static" standing satisfy the conditions of stationary stochastic processes.
2. The outcome of repeated tests in the same individual is the same at least in the statistical sense.
3. The postural movements are restricted to the immediate neighbourhood of an equilibrium which implies that the system can be described by linear approximations.
4. The predominantly slow modes and small magnitudes of the postural oscillations and the constant location in the vertical direction of the mass centre imply that the magnitude, the point of action and the line of action of the force acting on the area of support is determined by the mass of the body taken to be located at the mass center, which varies in a horizontal plane.
5. The assumptions no 1 and 3 imply Fourier analysis to be a suitable identification method for a time series of the postural oscillations in "static" standing (64). (It is assumed that the logarithmic values of the resulting multivariate variable are approximately normally distributed (39)).

I

RECORDING AND
IDENTIFICATION
OF TIME SERIES OF
OSCILLATIONS OF
THE MASS CENTRE
IN "STATIC" STANDING

By

HALDO ÖSTLUND

INTRODUCTION

Previously variations in the location of the head and other body parts have been recorded in persons, trying to stand immobile (18, 38, 47). Other workers have studied oscillations of the centre of mass (1, 4, 48, 55). Some authors have proposed estimates of the extent of the variation of such variables as adequate assessments of balance (18, 30, 47).

In the present study variations of the torques about the feet and about the forefeet and the heels respectively have been recorded and subjected to Fourier analysis (12) with estimation of the magnitude and the dynamic pattern of the oscillations.

METHODS

The technical equipment

Two scales built on strain-gauge principles (Bofors PVX-1, AB Bofors, Karlskoga, Sweden) (37) in connection with a measuring system (Bofors BKF-1, Bofors AB, Karlskoga, Sweden) constituted the technical equipment used for measurements of the torques about the feet and about the forefeet and the heels respectively. The scales were enclosed within rigid boxes, measuring $40.4 \times 15.4 \times 22.0$ cm. The resonance frequency was estimated to about 200 Hz, and damping ratio is approximately 20% (40). (Figs. 1 and 2), when the scales were unloaded as well as when a person (63 kg, 170 cm) was standing firmly with one foot on each scale as in the test situation.

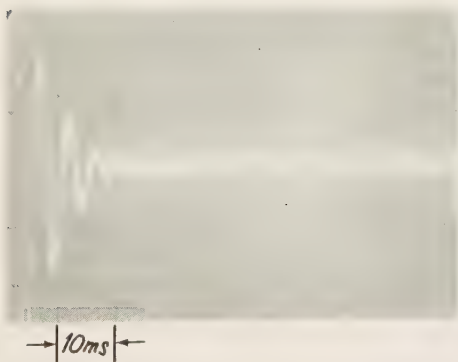


Fig 1. One scale was given a blow and the resulting oscillation was recorded as shown in the fig. The resonance frequency was rated to about 200 Hz.



Fig 2. Estimation of the resonance frequency as described in fig 1. The scales were loaded with a person (170 cm, 63 kg).

This value of the resonance frequency means an unbiased reproduction of examined frequencies in the 0—5 Hz band. The scales were coupled electrically to make the output proportional to the difference of load. The experimental results were recorded on a magnetic tape recorder (Labcorder, Epsylon Industries, England).

Test procedure

Four categories of tests were performed namely concerning postural oscillations in the frontal and sagittal plane, during standing with the eyes open and closed respectively. One test lasted 2 minutes.

Postural oscillations in the frontal plane were studied by placing the test subject in standing position on the scales with one foot in the middle of each scale and regarding oscillations in the sagittal plane with the forefeet on one scale and



Fig 3. The fig displays oscillations of (A-B), i.e. The difference in load between the right and left foot of a person standing immobile.



Fig 4. The curve in this figure displays the variation of the total body weight (A + B). The time scale and weight scale are the same as in fig 4. The oscillation in this figure are small and of much higher frequency than those in fig 4.

the heels on the other. The feet were in both cases roughly parallel and at the same distance from each other. (Fig. 3.)

The test subjects were allowed to get habituated to the situation for about 5 minutes, during which time the equipment was checked and reference data, 20 kg on each scale in turn, were recorded. The subjects were then told to stand on the scales in an upright posture with their arms hanging by the side and to remain as immobile as possible. They were then either told to look straight forward or to close their eyes and to keep to the given instructions during the test period. In order to reduce transient phenomena the recording was delayed 15 seconds after the administration of the test instructions. The test persons wore comfortable indoor clothes and thin socks or stockings.

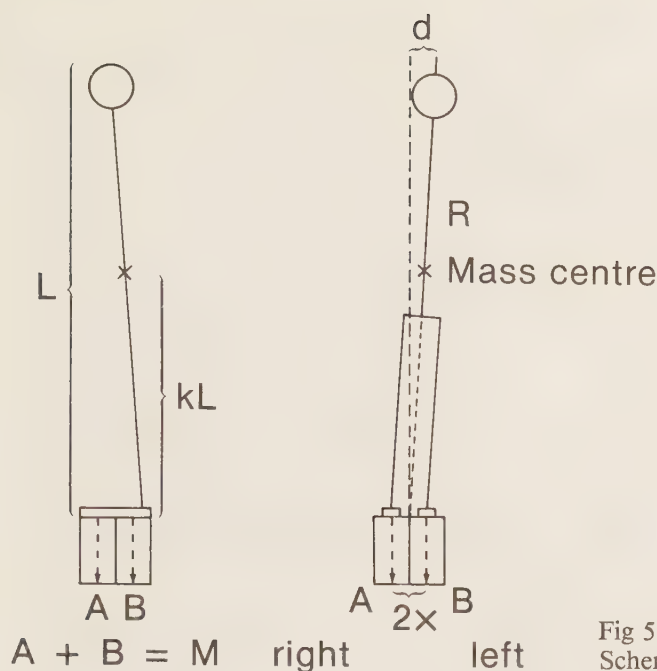


Fig 5.
Schematic picture of the test posture.

The physical meaning of the recorded signal

The interpretation is based upon assumption No 4 of the introduction. The following symbols are introduced (Fig 3):

The variable x denotes half the distance between the centres of pressure on the two scales. (This was not determined explicitly but 8 cm can be used as an approximate value, i.e. approximately half the distance between the mid points of the scales.) The body height is denoted L , the body mass M and k is the proportion of body height at which the centre of mass is located. (This was not experimentally determined but 0.56 might be used as a population average) (6, 33, 36, 70, 72). The angle, which the position vector of the mass centre, R , makes with the vertical, is denoted α , and the second time derivative of α is denoted $\ddot{\alpha}$. The origin of R was taken to be the point on the scales at which a single load gives zero signal in the relevant body plane. The literal A refers to the load on the right foot or the "forefeet" scale respectively and the literal B refers to the left foot or the heels scale.

Since α is assumed to be small $\sin \alpha$ is approximately equal to α and $\cos \alpha$ is approximately equal to 1. An implication of this is that postural movements of the mass centre occur approximately in the horizontal plane.

The following expression describes the recorded signal, when torques around the mass centre are neglected. The torque due to the inertia force of the acceleration of the mass centre is placed within brackets,

$$x (A-B) = MLk\alpha + (ML^2k^2\ddot{\alpha}) \quad \text{Eq. 1}$$

(A—B) is positive or negative, it is the originally recorded signal.

Division by L the factor ML thus eliminates the expressive influence of body weight and height but for the remaining influence of height upon the second factor within brackets. Besides division by ML multiplication by $180/\pi$ changes the angular unit from radians to degrees. The test criterion used is defined by this expression.

$$\frac{180}{\pi} \frac{(A-B)}{LM} = \frac{180}{\pi} \frac{\alpha k}{x} + \left(\frac{180}{\pi} \frac{Lk^2 \alpha''}{x} \right) \quad \text{Eq. 2}$$

Evidently the influence of the second factor is correlated with the magnitude of the acceleration of the motion, the numerical value of α'' being $4\pi^2 n^2$ (n = the frequency). An approximate value of α (= the inclination angle of the body) and d (= the measure of displacement of the vertex of the head) was demanded. The studied system (eq 1) is dynamic. The system is operated on by a dynamic system with the Laplace transform (3)

$$\frac{x}{S^2 ML^2 k^2 + MLk}$$

Then $\alpha = \frac{x}{S^2 ML^2 k^2 + MLk} (A-B)$

Only a stationary case was considered. The expression is simplified and reads

$$\alpha = \frac{x}{MLk} A-B \text{ and } d = \alpha L$$

By introduction of the approximate values, $x = 8$ cm and $k = 56\%$, the following expressions are obtained of the angle (α radians), which the position vector of the mass centre makes with the vertical, and the orthogonal distance (d cm) of the vertex of the head from the vertical coordinate axis, assuming the body to be rigid.

$$\frac{180}{\pi} \frac{.08}{.56} \frac{(A-B)}{ML} = \alpha \frac{180}{\pi} \text{ degrees} \quad \text{Eq. 3}$$

$$d = \alpha L \quad \text{Eq. 4}$$

The second term, in brackets, in eq. 2 was put equal to zero to get eq. 3, in order to simplify the expression, since it was supposed to be small in comparison. Eq. 4 follows directly from the geometry of Fig. 3 if α is small.

Time series analysis

The information of the recorded time series can be characterized by the variance and the autocorrelation function or the spectral density if the time series satisfy the conditions of stationary stochastic processes (39).

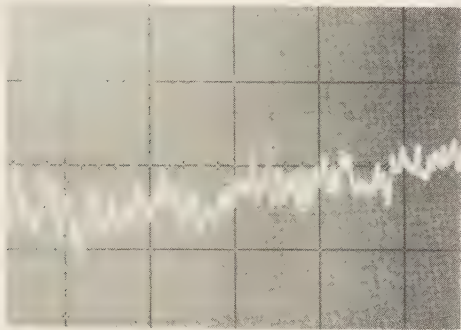


Fig 6. Example of oscillations in the frontal plane during a test period of two minutes.

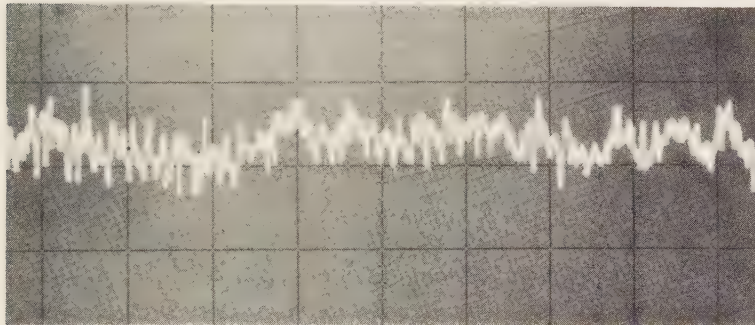


Fig 7. Example of oscillations in the frontal plane during a test period of four minutes.

An example of the time series is shown in Fig. 6, Fig 7 shows a time series obtained during a test period of 4 minutes instead of the usual 2 minutes in order to illustrate the property of stationarity.

Identification of the first and second half of a prolonged test period was made in 25 cases in a preliminary study to obtain a statistical measure of the stationarity (39).

The autocorrelation function gives the correlation between events separated by time intervals of different length. The spectral density function is formally the Fourier transform of the autocorrelation function. It gives the contribution to the variance from signal components of different frequency (12).

The numerical computations were carried out at Provdatacentralen, SAAB, Linköping, Sweden, using a digital computer. The series were filtered with an upper cutting off frequency at 10 Hz and then sampled. The calculations were based on the following parameters:

Frequency band studied	0—5 Hz
Sampling interval	$h = 0.04$ seconds
Max number of data	$N_{\max} = 3000$
Spectral resolution	$\Delta f = .25$ Hz

At a first step the mean and the linear trend were estimated and the residual variation about the line of regression was regarded as the relevant time series for further study. The variance was also estimated at this first step. Elimination of the contribution to the variance of a linear trend was done as suggested by Jenkins (39). The mean, the linear trend and the variance were expressed in kp, kp/min and kp^2 respectively.

The following formula was used to compute the autocorrelation function:

$$R_i = \frac{1}{N-i} \sum_{n=i}^{N-i} x_n \cdot x_{n+i} \cdot \left[1 + (-1)^n \cdot 0,14862 \right] \quad (i=0,1,2,\dots,m)$$

$R_0 = \text{the variance}$

The following formula was used to compute the spectral density function from the autocorrelation function:

$$G_i = 2h \cdot \left[R_0 + \sum_{n=1}^{m-1} R_n \cdot \cos \frac{ni\pi}{m} + (-1)^i \cdot R_m \right] \quad (i = 0,1,2,\dots,m)$$

The Hanning method was used in the smoothing of the spectra:

$$\begin{cases} \hat{G}_0 = .5 \cdot G_0 + .5 \cdot G_1 \\ \hat{G}_i = .25 \cdot G_{i-1} + .5 \cdot G_i + .25 \cdot G_{i+1} \\ \hat{G}_m = .5 \cdot G_{m-1} + .5 \cdot G_m \end{cases} \quad (i = 1,2,3,\dots,m-1)$$

Statistical methods

The results of the measurement of body movements in quasistationary standing consist of a multivariate variable with 13 components. The values were the decilogarithms of the standard deviation and the power spectral density of the time series, the latter described by 12 measures. Originally there were 21 frequency figures, but the number was reduced by taking the sum of the frequencies in the interval 2.75—5.00 Hz as they displayed seemingly pure random fluctuations.

Individual figures were supposed to be approximately normally distributed (39). In the case of the standard deviation of the time series the goodness of fit to normality was examined by a chi-square test.

Differences between result vectors were examined by Student's *t*-test. In order to examine the additional information given by the spectral density, when the standard deviation already was considered, Hotelling's T^2 -test was used. T^2 values were transformed into the corresponding *F*-values and estimation of additional information was made as described by Rao (61). In the test for additional information the number of components in the spectral density description was further reduced by considering the two lowest frequencies together with each other of the rest.

Differences between time series obtained under different conditions were examined by comparison of results obtained in the same person. Behavioural differences due to sex, age, height and weight were analysed from discrepancies between matched pairs. One quality at a time was allowed to vary while the others were kept as equal as possible. The correlation between the standard deviation of the time series and the spectral density was examined by the product-moment method. The correlation was also displayed diagrammatically. The sample distribution of the standard deviation was then divided into three levels $<m-\frac{1}{2}s$, $(m-\frac{1}{2}s)-(m+\frac{1}{2}s)$, $>m+\frac{1}{2}s$ and average frequency diagrams for each interval were drawn.

MATERIAL

The sample consisted of 89 healthy individuals, 70 men and 19 women with ages from 18 to 66 years. Due to specific experimental requirements in II of sample homogeneity the individuals above 50 years of age were all men. The mean and the standard deviation of height were 173 ± 7 cm and of weight 72 ± 11 kg. No signs of illness were found among the test subjects on a routine neurological examination but for a slight reduction of vibration sense in the legs in a few individuals above 60 years of age and small defects of hearing above 50 years of age.

RESULTS AND COMMENTS

Mean values and standard deviations for the standard deviation and the spectral density of the time series in the four test categories, frontal plane open and closed eyes and sagittal plane open and closed eyes, are presented in (Table 1) (unlog. and logaritmized values) and diagrams 1—4 of the appendix. The values show that the body oscillations are mainly of low velocity. In the frontal plane approximately 75% of the total variance is due to oscillations of frequencies below

0.375 Hz, roughly 85% is due to frequencies below 0.625 Hz and approximately 95% is due to frequencies below 1.125 Hz. Corresponding values for movements in the sagittal plane were 85%, 92% and approximately 97% respectively. Because of the small percentage of fast modes, influence of the inertia factor upon the total power of the time series would be comparatively small. This implicates that variation in body height would give a restricted contribution to the sample variance of the standard deviation of the time series.

(Table 2) contains the result of a chi-square test of the normality of the decilogarithmized standard deviation of the time series. The results do not contradict the assumption of normality.

(Table 3) shows the measures of angular deviation of the position vector of the centre of gravity from the vertical axis and the orthogonal distance of the head from the vertical coordinate axis respectively. (The measures were computed by using equations 3 and 4). The values are of the same order of magnitude as previously reported (1, 8, 47, 70).

(Table 4) shows differences in the same individual between the first and second half of a prolonged test period of four minutes duration in the frontal plane (one replication). Differences between a primary test and a replication for all four test categories are presented in (Table 5). Differences between standing with the eyes open and closed respectively and differences between postural oscillations in the frontal and sagittal plane are shown in (Table 6).

The result in (Table 4) indicate that in a primary test of prolonged duration the first half has a significantly greater standard deviation than the second half. In a replication there was no significant difference, however.

No significant differences were found between a primary test and a replication.

The results in (Table 6) of significantly larger oscillations in the sagittal plane than in the frontal plane and while standing with the eyes closed compared with standing with the eyes open are consistent with previous findings (30, 38, 65, 71). (Tables 7 and 8) show the results of an examination of the additional information of the spectral density, when the information due to the standard deviation of the time series was already considered. Only concerning comparison of oscillations in the sagittal plane while standing with the eyes open and closed respectively, statistically significant additional information from the spectral density was found.

Differences of the mean value and linear trend between a primary test and a replication in absolute values of angular deviation and distance (as described in Methods) support the assumption that the individual is able to choose a specific equilibrium position in "static" standing.

Noticeable is the insignificant difference between the standard deviation in the first and second half of a prolonged test, in this case, when unlogarithmized data were used, (Table 9).

The conclusion is that the test for postural movements in "static" standing shows a satisfactory degree of stationarity and regularity, (56) during a couple of minutes.

The association between the standard deviation and the spectral density of the time series is displayed by the correlation coefficients shown in (Table 10). The correlation is also shown in diagrams 5—7 in the appendix. In the diagrams the spectral density was drawn for three levels of the standard deviation of the time series $\leq m - \frac{1}{2}s$, $(m - \frac{1}{2}s) - (m + \frac{1}{2}s)$, $\geq m + \frac{1}{2}s$, for body movements in the frontal plane. Similar patterns were found in the case of the other three test categories. The diagrams were not displayed from considerations of space.

The presented results indicate that some disorganisation of the postural movements follow upon closure of the eyes. The stability control in the sagittal plane is more affected than that in the frontal plane. The spectral density shows the proportion of variance contributed by fluctuations of different frequency. The proportions can thus be conceived to assign the probability of events of different velocity. The measure of entropy (64) is usable as indicator of the randomness or the degree of order and certainty on the other hand. Calculations of measures of entropy can also be based upon the variance of the time series, see (64).

The entropy was calculated based upon the population means, (Table 1), in order to display the disorganization of standing caused by closure of the eyes.

Entropy of the spectral density, the probability of events of different frequency is indicated by p_i , is written $-\sum p_i \log_{10} p_i$ decidigits. Effects due to the correlations between the variables was not considered. Although the correlations are high, they are approximately the same for all four test categories and would not make comparison between the entropies for the four test categories impossible.

The following values were obtained. Frontal plane open eyes 0.6597, frontal plane closed eyes 0.6681, sagittal plane open eyes 0.5634 and sagittal plane closed eyes 0.6544.

There is practically no difference in the frontal plane, while the entropy is much greater, while standing with the eyes closed than with the eyes open in the sagittal plane. The results are roughly consistent with the results shown in (Table 7). Increase of irregularities and noise associated with disorganization of the righting reflexes upon closure of the eyes could be the explanation of the results.

The magnitude of the postural movements in "static" standing is about the same in women and men. (Table 11).

The results in (Table 12) show that the postural movements in the age group 51—66 years are somewhat smaller than in lower age groups. This is in contradiction with previous results (8, 57, 65). Sampling divergences might be the explanation. People ageing at most 66 were examined in this study.

(Table 13) shows no significant differences between pairs of individuals matched with regard to age, sex, height and weight but for somewhat greater content of slow modes in heavier persons. The lack of significant differences in the case of dissimilar height should be noticed. (Table 14) shows the protocol from the matching as median cuts and ranges for age, height and weight.

The figures of the power spectral density distribution are highly correlated. The two lowest frequency entries are negatively correlated with the others. In general the correlation between a frequency and its neighbours at a distance of one or two frequency units (0.25 Hz) is above 0.8 in most cases, except for the change between positive and negative correlation in the interval 0.25—0.5 Hz, see above.

DISCUSSION

The variations of the position of the mass centre of the body during a few minutes in erect quasistationary standing have been studied. The results indicate that the motion of the centre of mass can be regarded as a stationary time series. The system should be approximately linear since the movements are small. Then it would be possible to describe the behaviour of the system by a linear expression with constant coefficients (7.63). According to Norbert Wiener (64), Fourier analysis is then the most suitable method of analysis for the system. A parametric identification of the time series has been performed previously (32). Concerning the Method used see also (31).

Since the movements of the body in "static" standing are dominantly passive and the environment being inert except for the constant action of the force of gravity, the variance of the position of the mass center is supposedly due to a lack of inherent stability of the body. A dynamic feed-back control system such as the system of the righting reflexes (16) is then be indispensable to secure the stability of posture. For definition of posture reflexes see Magnus (43).

The situation can be diagrammatically described as follows:

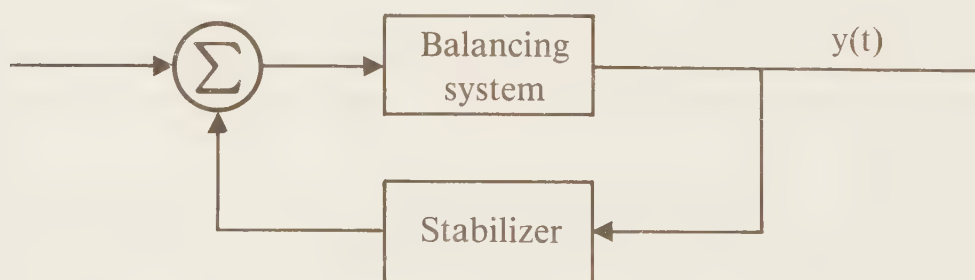


Fig. 8. The balancing system as a feedback control system.

$y(t)$ denotes the output.

There is substantial interindividual variation with regard to the magnitude and velocity of the oscillations of the mass centre. The individual regularity suggests the possibility to identify some of the variance as due to differences in personal

aim. That issue will be discussed in II. The interindividual variation is to a small degree accounted for by age differences, while the influence of sex, height and weight seems to be negligible at least in the statistical sense.

The meaning of the covariation between the magnitude and the frequency content of the oscillations might be that the system tends to reduce the uncertainty of posture associated with increasing oscillations. Assuming that the energy of the postural movements is always small in the interest of stability, large postural movements should be of low velocity, while small oscillations might be faster. It seems likely that small, rapid postural oscillations are controlled and to some extent generated at a low level of the central nervous system (CNS) and as a result stereotyped but fast due to a short reflex circuit (32, 45, 50). In cases with larger movements of the body the control reactions would be of higher origin in the CNS and then better integrated in space and time although maybe slower.

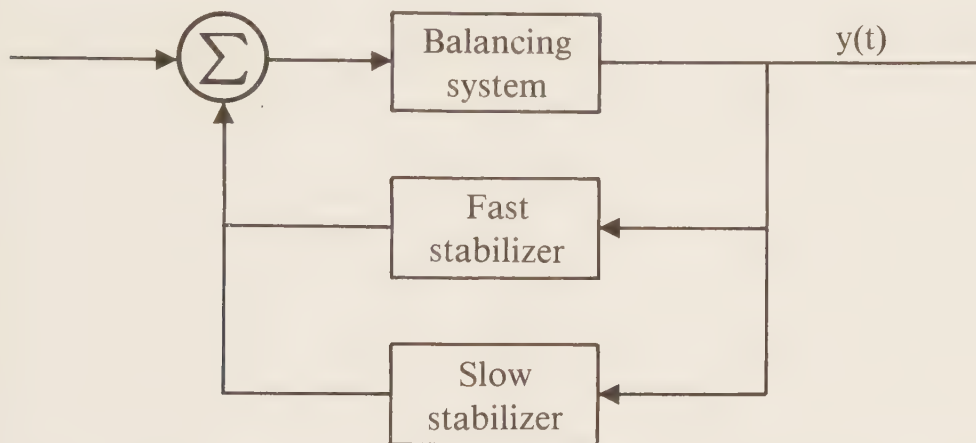


Fig. 9. Division of the stabilizer into one part with fast response and another part with slow response.

A complete identification of the balancing system is, however, impossible since both the input and the disturbances over the feed-back circuits are unknown. Some knowledge of how disturbances affect the system could be obtained by the introduction of external stimuli for example by putting a person on a movable platform, which is jerked and tilted. It has been shown in this study, consistently with the findings of other workers, that the body movements in "static" standing are greater in the sagittal than in the frontal plane and while standing with the eyes closed than while standing with the eyes open. These results also indicate the coming up of a disturbance of the ordinary strategy for stability control, after closure of the eyes, more prominently in the sagittal plane than in the frontal plane.

This study shows that it is at least occasionally possible to express the results of reproducible objective measurements from observation in an intact organism as relatively uncomplicated linear equations. The results of the arranged experimen-

tal situation should have a certain discriminatory power with regard to biological differences, which will be discussed in III and IV.

Although the results obtained in this study do not significantly falsify the hypothesis that the time series are stationary, they suggest, however, that some changes of the method would be necessary. Thus, the transient period in a primary test might be greater than the fifteen seconds considered sufficient in these recordings.

Tables I

Standard deviations are placed in brackets below corresponding mean values.

Table 1 Mean values and standard deviations (in brackets) for anlog. and dec ilogarithmized values in Normals.

Stand dev		0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75—5.00
FRONTAL PLANE OPEN EYES													
Normal natural	.854	.349	.419	.106	.052	.028	.015	.007	.004	.004	.003	.002	.009
N = 89	(.384)	(.074)	(.056)	(.049)	(.034)	(.027)	(.016)	(.007)	(.004)	(.004)	(.003)	(.003)	(.017)
Log.	-.106	-.468	-.382	-1.036	-1.405	-1.743	-2.026	-2.356	-2.550	-2.568	-2.731	-3.127	-2.543
	(.179)	(.102)	(.068)	(.255)	(.382)	(.634)	(.613)	(.597)	(.566)	(.409)	(.588)	(.863)	(.824)
FRONTAL PLANE CLOSED EYES													
Normal natural	1.100	.328	.414	.123	.056	.033	.018	.008	.004	.003	.002	.001	.006
N = 55	(.471)	(.078)	(.055)	(.053)	(.037)	(.030)	(.018)	(.007)	(.003)	(.002)	(.002)	(.001)	(.009)
Log.	.000	-.499	-.387	-.955	-1.350	-1.670	-1.970	-2.300	-2.480	-2.590	-2.740	-3.110	-2.650
	(.186)	(.119)	(.064)	(.208)	(.295)	(.456)	(.728)	(.670)	(.338)	(.351)	(.379)	(.632)	(.838)
SAGITTAL PLANE OPEN EYES													
Normal natural	1.570	.402	.453	.069	.027	.017	.011	.006	.003	.003	.002	.001	.004
N = 60	(.597)	(.060)	(.034)	(.042)	(.020)	(.013)	(.009)	(.005)	(.003)	(.002)	(.002)	(.001)	(.008)
Log.	.161	-.401	-.345	-1.330	-1.696	-1.909	-2.143	-2.411	-2.699	-2.818	-3.000	-3.373	-3.001
	(.182)	(.071)	(.035)	(.751)	(.379)	(.377)	(.410)	(.437)	(.655)	(.654)	(.673)	(.911)	(1.115)
SAGITTAL PLANE CLOSED EYES													
Normal natural	1.760	.352	.424	.101	.045	.030	.019	.010	.006	.004	.002	.001	.005
N = 43	(.716)	(.076)	(.054)	(.049)	(.033)	(.026)	(.017)	(.009)	(.005)	(.004)	(.002)	(.001)	(.005)
Log.	.212	-.466	-.377	-1.070	-1.470	-1.680	-1.920	-2.200	-2.440	-2.610	-2.820	-3.210	-2.700
	(.167)	(.106)	(.063)	(.272)	(.363)	(.396)	(.425)	(.413)	(.405)	(.403)	(.445)	(.890)	(.815)

Test category	< m-½s		(m-½s)-(m+½s)	>m+½s	Chi-square
Frontal plane open eyes	Exp. 27.40 Obtained 26		34.08 36	27.46 27	0.0964
Frontal plane closed eyes	16.97 19		21.06 17	16.97 19	0.6622
Sagittal plane open eyes	18.51 21		22.98 18	18.51 21	0.9190
Sagittal plane closed eyes	13.27 14		16.46 16	13.27 13	0.6288

Table 2 Chi-square test for goodness of fit to normality of the distribution of the logarithmized standard deviation, of the time series.

Test	Mean		Trend per minute		Standard deviation of the time series	
	Angle	distance	Angle	distance	Angle	distance
Frontal plane open eyes	0.343 (0.273)	1.035 (0.824)	0.147 (0.144)	0.444 (0.436)	0.122 (0.055)	0.368 (0.166)
Frontal plane closed eyes	0.354 (0.267)	1.070 (0.807)	0.139 (0.109)	0.418 (0.332)	0.157 (0.067)	0.474 (0.203)
Sagittal plane open eyes	0.697 (0.517)	2.105 (1.561)	0.197 (0.17)	0.595 (0.513)	0.224 (0.085)	0.677 (0.258)
Sagittal plane closed eyes	0.784 (0.473)	2.368 (1.428)	0.196 (0.156)	0.591 (0.470)	0.251 (0.102)	0.759 (0.309)

Table 3 Mean linear trend and standard deviation of the time series in degree angle and centimeter-distance of the head. (Eq 3,4)
Sample standard deviations are placed in brackets.

1st — 2nd half of a time series of 4 min. Frontal plane open eyes

	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Primary test	.082	.065	.014	-.160	-.144	-.230	-.287	-.266	-.272	-.142	-.058	-.167	-.097
N = 25	(.157)	(.115)	(.057)	(.261)	(.393)	(.800)	(.774)	(.676)	(.583)	(.301)	(.518)	(.923)	(.642)
t-value	2.558	2.769	1.203	-3.003	-1.795	-1.409	-1.817	-1.884	-2.286	-2.311	-.549	-.888	-.740
Replication	-.057	-.036	-.020	.005	.461	.165	.018	.001	.149	.206	.180	.123	.208
N = 14	(.194)	(.181)	(.072)	(.529)	(1.380)	(.622)	(.408)	(.415)	(.941)	(.812)	(1.210)	(1.480)	(1.330)
t-value	-.983	-.666	-.929	.032	1.118	.887	.147	.008	.530	.849	.497	.278	.523

Table 4 Test of stationarity by comparing the first and the second half of a time series of four minutes. One replication. Sample standard deviation are placed in brackets. The statistical significance was examined by the t-test.

Table 5

Test of regularity by comparing a primary test and a replication. Sample standard deviations are placed in brackets. The statistical significance was examined by the t-test.

PRIMARY TEST — REPLICATION													
Stand dev		0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
FRONTAL PLANE OPEN EYES													
N = 45													
t-value	-.049 (.194)	-.021 (.123)	-.016 (.063)	.148 (.934)	.031 (.505)	-.079 (.813)	-.089 (.754)	-.069 (.725)	-.028 (.745)	.041 (.524)	-.013 (.771)	-.020 (1.246)	.044 (1.140)
	-1.694	-1.145	-1.704	1.063	.412	-.652	-.792	-.638	-.252	.525	-.113	-.108	.259
FRONTAL PLANE CLOSED EYES													
N = 18													
t-value	-.052 (.208)	-.038 (.116)	-.022 (.056)	.041 (.271)	.076 (.320)	.017 (.379)	-.002 (.373)	.006 (.379)	-.030 (.386)	-.053 (.424)	-.093 (.494)	-.357 (922)	-.502 (1.124)
	-1.031	-1.350	-1.620	.624	.980	.185	-.022	.065	-.321	-.515	-.776	-1.597	-1.842
SAGITTAL PLANE OPEN EYES													
N = 20													
t-value	.002 (.122)	.007 (.067)	.004 (.025)	.040 (.257)	.007 (.259)	-.030 (.254)	-.038 (.275)	-.022 (.303)	-.040 (.328)	-.071 (.343)	-.108 (.439)	-.166 (.901)	.003 (1.111)
	.071	.455	.698	.678	.118	-.515	-.602	-.316	-.531	-.903	-1.073	-.803	.012
SAGITTAL PLANE CLOSED EYES													
N = 11													
t-value	.043 (.126)	.007 (.062)	.000 (.029)	-.090 (.267)	-.076 (.362)	-.008 (.317)	.005 (.300)	.005 (.256)	-.018 (.227)	-.111 (.244)	-.193 (.279)	-.145 (.245)	-.151 (.320)
	1.079	.357	.440	-1.066	-.664	-.080	.052	.020	-.251	-1.439	-2.140	-1.875	-1.492

Stand		0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75
dev													-5.00
FRONTAL - SAGITTAL PLANE OPEN EYES													
N=60 value		-.244	-.198	-.162	.380	.268	.186	.106	.215	.307	.369	.381	.569
		(.207)	(.920)	(.883)	(.793)	(.547)	(.580)	(.638)	(.819)	(.803)	(.841)	(1.291)	(1.526)
		-8.821	-1.610	-1.373	3.586	5.940	2.380	1.243	1.964	2.861	3.284	2.208	2.790
FRONTAL - SAGITTAL PLANE CLOSED EYES													
N=40 value		-.210	-.060	-.021	.183	.099	.058	-.007	.009	.060	.142	.171	.147
		(.184)	(.158)	(.088)	(.358)	(.528)	(.527)	(.451)	(.489)	(.515)	(.494)	(.799)	(.846)
		-7.128	-2.371	-1.490	3.192	2.619	.687	-.097	.115	.728	1.795	1.337	1.085
FRONTAL PLANE OPEN-CLOSED EYES													
N=55 value		-.110	.021	.002	-.025	.032	.042	.006	-.009	.043	.020	.025	.129
		(.153)	(.119)	(.063)	(.238)	(.400)	(.657)	(.652)	(.354)	(.382)	(.610)	(.884)	(.968)
		-5.283	1.297	.233	-.722	.586	.470	.067	-.186	.827	.241	.208	.979
SAGITTAL PLANE OPEN-CLOSED EYES													
N=43 value		-.059	.067	.031	-.330	-.233	-.227	-.218	-.276	-.226	-.198	-.230	-.378
		(.146)	(.199)	(.056)	(.922)	(.419)	(.418)	(.442)	(.691)	(.708)	(.755)	(1.334)	(1.499)
		-2.615	2.182	3.588	-2.320	-3.645	-3.519	-3.196	-2.588	-2.069	-1.670	-1.161	-1.635

Table 6

Differences between oscillations in the frontal and the sagittal plane and during standing with the eyes open and closed. Sample standard deviations are placed in brackets.

Test	Stand. dev. and spectr. dens.		Additive information due to the spectr. dens.	
	F-value	Df.	F-value	Df.
Frontal-sagittal plane open eyes (N = 60)	12.35	8/52	1.37	7/52
Frontal-sagittal plane closed eyes (N = 40)	6.58	8/32	.65	7/32
Frontal plane open-closed eyes (N = 55)	5.66	8/47	1.87	7/47
Sagittal plane open-closed eyes (N = 43)	7.77	8/35	6.95	7/35

Table 7 T²-test for differences between postural oscillations in the frontal and sagittal plane and between standing with the eyes open and closed. (T² values were transformed into F-values). A study of the additional information due to the spectral density represented by these frequencies. 0.00, 0.25, 0.75, 1.25, 1.75, 2.25, 2.75—5.00.

Test	Stand. dev. and spectr. dens.		Additive information due to the spectr. dens.	
	F-value	Df.	F-value	Df.
1st — 2nd HALF OF A TIME SERIES OF 4 MIN.				
Frontal plane open eyes (N = 25)	1.99	8/17	1.40	7/17

PRIMARY TEST — REPLICATION

Frontal plane open eyes (N = 45)	1.80	8/37	1.57	7/37
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Table 8 T²-test for regularity and stationarity with a study of the additional information due to the spectral density. (T² values were transformed into F-values). The spectral density was represented by these frequencies 0.00, 0.25, 0.75, 1.25, 1.75, 2.25, 2.75—5.00.

Test	Spectral mean		Trend		Standard deviation	
	Angle	cm-distance	Angle	cm-distance	Angle	cm-distance
1st-2nd half of a test in frontal plane. (N = 25)	-.057 (.392)	-.172 (1.184)	-.025 (.323)	-.075 (.976)	.023 (.057)	.072 (.17)
Prim.test-replication						
Frontal plane open eyes (N = 45)	-.077 (.405)	-.234 (1.223)	-.004 (.285)	.013 (.860)	-.015 (.057)	-.046 (.174)
Frontal plane closed eyes (N = 18)	.181 (.485)	.547 (1.465)	.008 (.243)	.025 (.732)	.015 (.076)	-.045 (.231)
Sagittal plane open eyes (N = 20)	.061 (.408)	.186 (1.233)	.095 (.262)	.284 (.792)	.001 (.064)	.039 (.193)
Sagittal plane closed eyes (N = 11)	-.089 (.427)	-.271 (1.291)	.024 (.262)	.072 (.793)	.001 (.038)	.038 (.1146)

Table 9 Differences between the mean, the linear trend and the standard deviation of the first and second half of a series of 4 min, and differences between a primary test and a replication in all four test categories, expr. in angle of inclination (α) and distance of the head (d) (Eq 3,4).

Test	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Frontal plane open eyes (N = 89)	.44	.38	-.49	-.44	-.36	-.35	-.35	-.41	-.59	-.46	-.30	-.40
Sagittal plane open eyes (N = 60)	.75	.69	-.41	-.61	-.55	-.61	-.59	-.47	-.50	-.49	-.35	-.42
Frontal plane open eyes (N = 55)	.30	.29	-.35	-.43	-.21	.12	.12	-.17	-.38	-.21	-.20	-.19
Sagittal plane open eyes (N = 43)	.42	.28	-.47	-.56	-.49	-.52	-.52	-.43	-.45	-.40	-.17	-.31

Table 10 Correlations between the standard deviation and the spectral density figures of the time series.

Test Category	Women age 18—50		Men age 18—50	
	Mean	St.dev.	Mean	St.dev.
Frontal plane open eyes	.020 n = 19	.155	.020 n = 21	.167
Frontal plane closed eyes	.025 n = 13	.145	.034 n = 16	.205
Sagittal plane open eyes	.190 n = 17	.164	.164 n = 19	.221
Sagittal plane closed eyes	.262 n = 14	.145	.191 n = 16	.170

Table 11 Mean values and standard deviations of the decilogarithmized standard deviation of time series in women and men.

Test Category	Age 18—35		Age 36—50		Age 51—66	
	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.
Frontal plane open eyes	.023 n = 24	.200	-.028 n = 16	.105	-.173 n = 49	.155
Frontal plane closed eyes	.029 n = 17	.152	.030 n = 12	.202	-.032 n = 26	.192
Sagittal plane open eyes	.166 n = 20	.179	.192 n = 16	.134	.135 n = 24	.205
Sagittal plane closed eyes	.220 n = 16	.176	.235 n = 14	.116	.177 n = 13	.192

Table 12 Mean values and standard deviations of the decilogarithmized standard deviation of time series in the three age groups: 18—35, 36—50, 51—66.

Property tested	Stand dev	2.75—											
		0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	5.00
Identical	.016	.027	.008	-.087	-.039	.086	.095	.055	.052	-.098	-.184	.085	.203
N = 20	(.101)	(.175)	(.120)	(.450)	(.695)	(1.236)	(1.134)	(1.016)	(1.014)	(.681)	(1.124)	(1.491)	(1.680)
t-value	.708	.673	.290	-.843	-.245	.303	.366	.236	.223	-.628	-.713	.249	.526
Sex (woman-													
man)	-.070	.045	.036	.031	.054	-.088	-.219	-.278	-.270	-.274	-.236	-.227	.071
N = 9	(.160)	(.172)	(.119)	(.290)	(.481)	(.578)	(.518)	(.447)	(.428)	(.385)	(.443)	(.712)	(1.725)
t-value	-1.238	.740	.856	.303	.318	-.431	-1.195	-1.759	-1.708	-2.013	-1.507	-.901	.116
Age	.048	-.062	-.026	.157	.134	.124	.148	.084	.105	-.002	-.024	.396	.555
N = 17	(.262)	(.155)	(.116)	(.299)	(.468)	(.475)	(.393)	(.421)	(.389)	(.454)	(.489)	(1.331)	(1.431)
t-value	.732	-1.600	-.411	2.100	1.146	1.044	1.507	.798	1.080	-.017	-.196	1.190	1.551
Height	-.052	-.003	-.009	-.053	-.059	-.171	-.165	-.216	-.162	-.013	-.053	-.220	-.259
N = 23	(.277)	(.149)	(.098)	(.427)	(.602)	(1.139)	(1.101)	(1.014)	(1.007)	(.583)	(.637)	(1.448)	(1.427)
t-value	-.880	-.095	-.430	-.582	-.460	-.704	-.703	-1.000	-.755	-.105	-.390	-.713	-.851
Weight	-.020	.043	.026	-.118	-.176	-.160	-.140	-.159	-.136	-.104	-.186	-.314	-.456
N = 25	(.166)	(.110)	(.067)	(.297)	(.340)	(.374)	(.372)	(.412)	(.454)	(.537)	(.947)	(1.138)	(1.289)
t-value	-.590	1.916	1.803	-1.947	-2.536	-2.096	-1.844	-1.891	-1.468	-.948	-.962	-1.352	-1.760

Table 13

t-test of differences between matched pairs. (Matched with regard to sex, age, height and weight).

II

PATTERNS OF QUASISTATIONARY STANDING AS INDICATORS OF DIMENSIONS OF PERSONALITY

By

G. EBERHARD NYMAN and HALDO ÖSTLUND

INTRODUCTION

The ability of Man to obtain and maintain homeostasis is constantly challenged by a complex and variable environment. The purpose and strategy of the organism would in complex situations to a substantial degree be determined by "voluntary" factors. In quasistationary standing "automatic" mechanisms would be sufficient.

Since the postural oscillations of the mass centre in "static" standing define a time series possible to be described approximately by a linear expression with constant coefficients, variations in personality will probably at most manifest themselves as differences in the general pattern of behaviour or cognitive style.

Relations between personality, described according to Sjöbring (67) and characteristics of "static" standing are examined in this paper.

The personality system of Sjöbring

The personality system of Sjöbring originated from a concept regarding the dispositional background of certain "functional" abnormal states: psychasthenic reactions, affective disorders and hysterical deficiency were thought to correspond to genotypical dispositions, which form the minus poles of four "fundamental" dimensions of interindividual variation. Descriptions of the syndromes at the opposite poles of the dimensions, and the hypothesis of the dimensions varying independently, result in their turn into a general theory of *subjective experience*, a point-to-point corresponding physiological (metapsychological) construct, and a theory considering the relation between interindividual variation and the physiological model.

The *psychological model* gives four parameters of individual affective experience. Its "general character" is finality, a striving towards a goal. One parameter is *degree of pleasure*, corresponding to the individual's experience of distance or proximity to the goal of his actual striving. Displeasure-pleasure can be more or less *intense*. It can vary in *depth*, corresponding to the subject's experience of how much the goal aimed at means to him, its importance and value. Finally, experience might be more or less free, i.e. range from impeded, hampered, to easy, free, irrespectively of its intensity or depth.

The relations between the parameters mentioned are given by means of a metapsychological construct in which they are conceived as spatial and energetic properties of a neurophysiological process. This might have a certain *extent*, i.e. a certain amount of nervous tissue might be involved.

"Physiological" extent corresponds to "psychological" depth. Functional systems of the nervous substratum offer greater or lesser *resistance*. Through repeated tracking resistance and energy consumption diminish. *Pari passu*, in the realm of experience, feeling grows freer. Extent and resistance both determine the

rate of energy expenditure of the process, which, in the language of experience, is the intensity of feeling.

When nervous tissue is repeatedly being tracked or habituated, it is said to acquire increased *potentiality*. Highly potential substratum needs less energy when functioning. Routine functions such as locomotion and talking might exemplify the functioning of highly potential nervous substratum.

A unification of several partial moments into one efficient, or concordant system leads to a high degree of *pleasure*. But as increasing potentiality must also imply less resistance, maximal concordance will mean a state of "pure pleasure" but minimal intensity.

From the point of view of differential psychology individuals vary with regard to assumed genotypical dimensions. The first of these is *capacity*, which means disposition to intellectual development. *Validity* is an "energetic" dimension which reflects the average effect level of the nervous substratum, or the maximal energy attainable.

Stability refers to the degree of potentiality.

Solidity, finally, implies the inertia when gaining and losing potentiality.

Variation in capacity is one from dull, to richly endowed. Validity ranges from cautious, tense, fatiguable, to expansive, efficient, active.

The supervalid individual, on the other hand, is characterized by a secure and efficient behaviour.

Stability varies from warm, concrete, naive, motorically childish to cool, nimble, sophisticated, abstract. Since substable individuals cannot attain any very high degree of potentiality, they seem less habituated in feeling and behaviour than the more "automatized", superstable ones. Subsolid individuals have a low inertia, they attain their individual maxima of potentiality after relatively few moments of learning, and after relatively short periods of inactivity the corresponding functional systems loose the potentiality gained.

Thus, they appear learnable, variable, inconstant. At any moment, relatively few functions are active, so they are also narrow and acting at the spur of the moment.

Correspondingly, supersolid individuals are circumspective, rational, and dry.

Hypothetical relations between dimensions of personality according to Sjöbring and patterns of quasistationary standing

The irregular swings of the body, to and fro, in quasistationary standing are supposed to be controlled with regard to magnitude and velocity by a control system in the interest of stability of the posture. To some extent the setting up of acceptable limits might be determined by the habitual pattern of the individual behaviour (32). Concerning the association between the extent of postural sway and psychological factors see Eysenck (24).

The supervalid person, who has great resources of energy momentarily available is prepared, industrious, confident and independent in contrast to the subvalid person, who displays a comparatively restricted, cautious and routine way of living. A high degree of validity might then in quasistationary standing correspond to a comparatively high energy level of the body movements, meaning a large total power and a relatively large content of fast modes.

A superstable person displays a high degree of integration and perfection of activity. He is a lover of ease and is cold and detached. Activity runs easy in situations where adaptation is good. A superstable individual takes most interest in ideas and is abstract in thought. One might compare the superstable individual to an aircraft equipped with a good autopilot, which takes care of current problems, while the pilot gets the opportunity to concentrate upon other issues. The energy content of the movements is then supposed to be kept low.

In the quasistationary standing this would mean a small total power and a large content of slow modes. The converse would be true for the substable individual, who has a firm foundation in concrete reality, is less skilful in reflexion, planning and methodology and in whom activity is less integrated and less perfect.

Since the behaviour in "static" standing seems to be approximately stationary, no manifestations of the flexibility and tendency to short term control in subsolid individuals are expected. The fastness of action in subsolid persons might, however, result in a great content of fast postural movements. Capacity, on the other hand, does not lend itself to hypothesis.

MATERIAL AND METHODS

The material consisted of 36 healthy men with median and range of age 54, 51—66 years, of height 173, 158—182 cm, and of weight 74, 51—89 kg. The oscillations in the frontal plane of the centre of mass during "static" standing with the eyes open were recorded. In 26 individuals a replication of the test was performed. The time series were identified as described in I. Logarithmized values of the standard deviation of the time series together with logarithmized values of the power spectral density entries, 13 numbers, constituted the result vector.

The personality dimension described by Sjöbring (67) were estimated by subjective rating with regard to capacity, validity, stability and solidity (Table 1) and with regard to validity, stability and solidity by the MNT-method (54) (Table 2). Six descriptive variables (Tables 3—5) for each of the three dimensions, validity, stability and solidity, were estimated by subjective rating (53). The results of the subjective rating were described in a scale 1—7.

The assessment of personality traits was performed during short single interviews. The sessions varied in length between 20 and 40 minutes. They were performed

med in privacy and did not follow any very strict planning. The individual's name, occupation, marital status, and scholastic education were registered at the beginning of the interview. An informal conversation was aimed at in order to try to make the subject expose his personality through spontaneous talk. The topics of conversation were decidedly neutral and centred on personal interests, plans for future, and hobbies.

The rating of the hypothetic variables of Sjöbring was performed before the opinion of the individual concerning his own personality make-up had been asked for. Observation of varying speeds, ranges, and patterns of expressive behaviour were important for the evaluation of hypothetical, as well as descriptive traits.

The MNT-questionnaires (54, 23) contain 60 items, 20 each concerning validity, stability, and solidity, ordered at random. The questions are simply answered with Yes or No.

The schedules were filled in by the subjects some days before the interview took place.

Individual correlations between personality variables and data obtained from the time series analysis were estimated by the product-moment method. Only correlations of absolute value ≥ 0.1 are displayed.

The method of canonical correlation (2) was used for estimation of the association between the result vectors obtained from the time series analysis and vectors of personality variables. Measures of the total power and of the time constant have previously been assumed to describe the information content of the time series in "static" standing rather well (32). It was then considered adequate to assign rank 2 for the correlation matrices upon which estimation of the canonical correlations was based, which also is the number of relevant correlations. The calculation was made at Lund's data central (Lund, Sweden), using the standard program BMD06M.

RESULTS

The sample means and standard deviations for personality dimensions estimated by subjective rating are shown in (Table 1). (Table 2) contains values for personality dimensions estimated by the MNT-method. (Tables 3—5) display the mean values and the standard deviations for descriptive variables concerning in turn validity, stability and solidity. Subjectively rated hypothetic variables and descriptive variables are correlated at about +0.7 for each personality dimension. Variables obtained by subjective rating concerning validity and solidity are generally negatively correlated at about -0.5. The correlations between estimates of the hypothetic dimensions of personality, estimated by subjective rating, and

those estimated by the MNT-method respectively are generally of small magnitude, roughly about 0.2—0.3. In the case of solidity the correlation was in fact negative.

(Table 6) contains the mean values and the standard deviations for the data obtained in the time series analysis.

There is a significant positive correlation between validity estimated by the MNT-method and the standard deviation of the time series. The result, which is in accordance with expectation, is further validated by the fact that a similar result was obtained in a replication. (Table 7).

Stability subjectively rated is, as expected, correlated with the content of very slow modes. (Table 8). The result concerning stability gains support from the results concerning descriptive variables referring to stability. (Table 10). Similar results were obtained both in a primary test and in a replication.

In the case of validity and stability there is a weak correspondence between the results obtained by subjective rating and by the MNT-method. The correlations concerning descriptive variables referring to validity presented in (Table 9) are generally of small magnitude and are inconclusive.

There are no significant correlations with regard to solidity and capacity. There is, however, a certain resemblance between the correlation patterns in the case of subjectively rated variables concerning solidity, (Table 11), and the results concerning subjectively rated stability. (Table 10).

The canonical correlations, presented in (Table 12), are supposed to indicate that a substantial part of the interindividual variation of the time series is accounted for by differences in personality.

The canonical variables corresponding to the result in (Table 12) are in the case of personality variables estimated by subjective rating dominated by stability and to some degree capacity and solidity on one hand and spectral densities on the other. In the case of variables estimated by the MNT-method, validity and the standard deviation of the time series respectively dominate at least in the first variables.

The canonical correlations are greater than individual correlations. Perhaps it is adequate to assign rank one for the correlation matrices 9—11 since the descriptive personality variables are rather highly positively correlated, besides the fact that they are supposed to measure the same quality based on a unitary conception.

DISCUSSION

This study suggests the possibility to assess personality factors from time series of body movements during "static" standing. A certain construct validation (13) of the personality system of Sjöbring has then been attained, mainly with regard to validity and stability.

It is evident, concerning the experimental model of "static" standing, that one must not presume an unambiguous relation between the demands expressed in a test instruction and the outcome of the examination. Differences are present which are related to variations in personality and they might be referred to as dissimilarities of aim.

Tables II

Standard deviations are placed in brackets below corresponding mean values.

Table 1
Mean and standard deviation of hypothetical personality dimensions subjectively rated, scale 1—7

	Mean	St dev
Capacity	4.40541	1.75530
Validity	4.89189	1.39012
Stability	3.94595	1.87003
Solidity	4.02703	1.25801

Table 2
Mean and standard deviation of hypothetical personality dimensions estimated by MNT

	Mean	St dev
Validity	14.000	3.697
Stability	7.703	2.344
Solidity	13.865	2.720

Table 3
Mean and standard deviation subjectively rated (scale 1—7) descriptive personality variables referring to validity

	Mean	St dev
Sedative — Expansive	4.351	1.620
Cautious — Daring	4.432	1.425
Scrupulous — Extravagant	4.514	1.283
Tense — Free	4.730	1.627
Uneasy — Calm	4.865	1.357
Fatiguable — Tough	4.838	1.385

Table 4
Mean and standard deviation subjectively rated (scale 1—7) descriptive personality variables referring to stability

	Mean	St dev
Warm — Cool	3.892	1.350
Personal — Indifferent	3.703	1.450
Concrete — Abstract	3.378	1.233
Clumsy — Proficient	4.378	1.497
Heavy — Nimble	4.108	1.410
Industrious — Indolent	3.865	1.512

Table 5
Mean and standard deviation subjectively rated (scale 1—7) descriptive personality variables referring to solidity

	Mean	St dev
Quick — Slow	3.838	1.259
Mobile — Persevering	3.432	1.345
Pleasing — Dry	4.108	1.022
Suggestible — Unimpressible	4.297	1.266
Subjective — Objective	4.027	1.424
Impulsive — Considerate	4.189	1.578

0.00Hz	0.25Hz	0.50Hz	0.75Hz	1.00Hz	1.25Hz	1.50Hz	1.75Hz	2.00Hz	2.25Hz	2.50Hz	2.75— 5.00Hz	Stand dev
-.533 (.118)	-.453 (.081)	-.883 (.269)	-.933 (.476)	-1.233 (.902)	-1.673 (.863)	-2.033 (.863)	-2.363 (.778)	-2.403 (.411)	-2.623 (.456)	-2.923 (1.106)	-2.213 (.935)	-.248 (.155)

Table 6 Mean values and standard deviation (in brackets) of the time series characters

Pers. Dimensions	Time ser. charact.												
	0.00Hz	0.25Hz	0.50Hz	0.75Hz	1.00Hz	1.25Hz	1.50Hz	1.75Hz	2.00Hz	2.25Hz	2.50Hz	2.75— 5.00Hz	Stan dev
VALIDITY													
primary test	—	—	—	—	.13	.14	.11	—	—	—	—	—	.46
replication	—	—	—	—	.14	.11	—	—	—	—	—	—	.49
STABILITY													
primary test	.18	—	-.20	-.12	-.13	-.14	-.12	-.13	—	—	-.10	-.10	-.12
replication	—	—	-.11	—	-.11	-.10	—	—	—	—	—	—	—
SOLIDITY													
primary text	-.14	-.19	—	—	—	—	—	—	.13	.14	.12	.14	—
replication	-.20	-.16	—	—	—	—	—	—	.23	.21	.19	.14	—

Table 7 Individual correlations between personality dimensions estimated by MNT scale and the time series characters

Pers. Dimensions	Time ser. charact.												Stan dev
	0.00Hz	0.25Hz	0.50Hz	0.75Hz	1.00Hz	1.25Hz	1.50Hz	1.75Hz	2.00Hz	2.25Hz	2.50Hz	2.75— 5.00Hz	
INTELLIGENCE													
primary test	—	-.12	—	.15	—	—	—	—	—	—	.27	.28	-.14
replication	—	—	—	—	—	—	—	—	—	—	.15	.19	-.35
VALIDITY													
primary test	—	—	-.10	—	—	—	—	—	—	—	-.12	-.13	.21
replication	—	—	—	—	—	—	—	—	—	—	-.11	—	.22
STABILITY													
primary test	.27	.31	-.10	-.11	—	—	—	—	—	—	—	—	—
replication	—	.27	.11	—	—	—	—	—	—	—	—	—	-.14
SOLIDITY													
primary test	—	—	-.13	-.21	-.19	-.17	-.15	—	—	—	—	—	-.16
replication	.15	—	—	-.21	-.22	-.19	—	—	—	—	—	—	—

Table 8 Individual correlations between personality dimensions subjectively rated and the time series characters

Pers. Dimensions	Time ser. charact.												Stan dev
	0.00Hz	0.25Hz	0.50Hz	0.75Hz	1.00Hz	1.25Hz	1.50Hz	1.75Hz	2.00Hz	2.25Hz	2.50Hz	2.75— 5.00Hz	
Seditativ—Expansiv													
primary test	-.13	-.21	—	.23	.26	.26	.24	.20	.11	.13	—	—	—
replication	—	-.11	—	—	.14	.18	—	—	—	-.12	—	—	—
Cautious—Daring													
primary test	—	—	—	—	—	—	—	—	-.13	-.12	—	-.16	.18
replication	—	—	—	—	—	—	—	—	-.15	-.21	—	-.18	—
Scrupulous—Extravagant													
primary test	—	—	—	—	.15	.14	.12	—	—	—	-.10	-.16	.26
replication	—	—	—	—	—	—	—	—	—	—	—	—	—
Tense—Free													
primary test	.13	—	-.14	—	—	—	—	—	—	—	—	—	.21
replication	.13	—	-.17	—	—	—	—	—	—	—	—	—	—
Uneasy—Calm													
primary test	—	—	—	.11	.17	.17	.16	.14	—	—	—	—	.11
replication	—	—	—	—	—	-.12	-.22	-.25	—	—	—	—	.20
Fatiguable—Tough													
primary test	—	—	—	—	—	—	—	—	—	—	-.11	—	.13
replication	—	—	—	—	—	—	—	—	—	—	—	—	.13

Table 9

Individual correlations between descriptive personality variables referring to validity and the time series characters

Pers. variables	Time ser. charact.												Stan dev
	0.00Hz	0.25Hz	0.50Hz	0.75Hz	1.00Hz	1.25Hz	1.50Hz	1.75Hz	2.00Hz	2.25Hz	2.50Hz	2.75— 5.00Hz	
Warm—Cool													
primary test	.32	.41	—	—	—	—	—	—	—	—	—	—	—
replication	.24	.35	—	—	—	—	—	—	-.11	—	—	—	—
Personal—Indifferent													
primary test	.26	.35	—	-.14	-.12	-.11	-.13	-.13	-.17	-.12	—	—	.10
replication	—	—	—	-.15	-.23	—	—	.10	.14	.18	—	—	-.15
Concrete—Abstract													
primary test	—	—	.34	.30	.31	.30	.30	.29	.23	.24	.30	.30	-.25
replication	—	—	—	—	—	.12	.16	.16	.13	.11	.10	.10	-.18
Clumsy—Proficient													
primary test	.13	.20	.10	—	—	—	—	—	—	—	—	—	-.13
replication	.15	.28	—	—	—	—	—	—	—	—	—	—	—
Heavy—Nimble													
primary test	.10	.11	—	—	.16	.17	.16	.15	—	—	—	—	—
replication	.13	.19	—	—	-.25	-.15	-.13	—	—	—	—	—	—
Industrious—Indolent													
primary test	.31	.27	-.15	—	—	—	—	—	—	—	—	—	—
replication	.24	.32	-.11	—	—	—	—	—	—	—	—	—	—

Table 10 Individual correlations between descriptive personality variables referring to stability and the time series characters

Pers. variables	Time ser. charact.													Stan dev
	0.00Hz	0.25Hz	0.50Hz	0.75Hz	1.00Hz	1.25Hz	1.50Hz	1.75Hz	2.00Hz	2.25Hz	2.50Hz	2.75— 5.00Hz		
Quick—Slow primary test	.20	.25	—	-.20	-.22	-.23	-.23	-.20	-.19	-.16	—	—	—	
replication	.10	.13	—	—	—	—	—	-.17	-.22	-.19	—	—	—	
Mobile—Persevering primary test	-.10	—	—	.16	-.23	-.21	-.18	-.16	—	—	—	—	—	
replication	—	—	—	—	—	—	—	—	—	—	—	—	—	
Pleasing—Dry primary test	-.14	—	—	—	—	—	—	—	—	—	—	—	-.11	
replication	—	—	—	—	—	—	—	—	—	—	—	—	—	
Suggestible—Unimpressible primary test	—	—	-.10	-.10	-.16	-.19	-.16	-.16	—	—	—	—	—	
replication	—	—	-.14	—	—	.12	.23	.30	—	—	—	—	—	
Subjective—Objective primary test	—	—	—	-.11	-.19	-.17	-.15	-.16	—	—	—	—	.17	
replication	—	—	—	-.26	—	—	—	—	—	—	—	—	—	
Impulsive—Considerate primary test	—	—	—	-.17	-.19	-.17	-.13	—	—	—	—	—	-.22	
replication	—	—	—	-.17	—	—	—	—	—	—	—	—	—	

Table 11 Individual correlations between descriptive personality variables referring to solidity and the time series characters

Personal dimension	Canonical correlations	
	1 st	2nd
Hypothetic personal dimension subjectively rated	0.641	0.615
Hypothetic personal dimension estimated by MNT	0.772	0.615
Descriptive variables subjectively rated		
1. Referring to validity	0.918	0.722
2. Referring to stability	0.724	0.717
3. Referring to solidity	0.796	0.671

Table 12 Canonical correlations between vectors of personality and the result vector in "static" standing

III

QUASISTATIONARY STANDING IN SOME NEUROLOGICAL DISORDERS

By

HALDO ÖSTLUND

INTRODUCTION

The presumption that stability in "static" standing is dependent upon the action of the righting reflexes, see I, should imply the possibility to find differences between neurological disorders by observation of the kinetic events present in "static" standing. In a previous study psychogenic disorders of balance were found to differ from organic disorders by a greater content of slow movements (56). The explanation might be that the large oscillations in psychogenic disorders are motivated by the purpose to attract attention and to gain some advantage from the illness (11), i.e. an abnormality of aim. The intact or insignificantly damaged, (i.e. unable to account for the disturbed balance) "automatic" postural mechanisms would in the case of such an abnormality continue to restrict the energy content of the body movements in the interest of the stability of posture, I. In organic disorders on the other hand the wide range oscillations are the consequence of neuropathology.

In ataxia for instance, there is an inability to maintain a uniform muscular contraction, under constant isometric, isotonic and shifting conditions (45). In Sensory ataxia the motor disturbances are loose, flailing (46), contrasting with an alternating character in Cerebellar ataxia (46, 26). Manifested by an almost regular tremor (3 Hz) of the feet in ataxia due to alcoholism (66).

Somatotopically one might assume that lateral Cerebellar lesions cause ataxia of the extremities while medial lesions cause ataxia of the trunk (17).

Cerebellar ataxia due to alcoholism is mainly caused by a degeneration of the anterior — superior portions of the vermis (26). In Sensory ataxia the disturbed sensory input is to some degree compensated for by optic control (15) meaning a more or less significant aggravation of the disturbances of motion and balance upon blindfolding (62, 73). Some change upon blindfolding is suggested by the observation that patients with onesided labyrinthine destruction experience some difficulty of balance, when standing in darkness (5, 10). Although the postural mechanisms have deteriorated to various degrees in Parkinson's disease (14, 9, 44), the presence of rigidity (which means an almost constant resistance against passive movements over their whole range (14, 9, 44) would damp tendencies towards hunting. In contrast to the "static" effect of rigidity, the resistance against passive movements in spasticity is "dynamic" to some extent (58). Since the Spinal sensory, the vestibular and optic reflexes may have deteriorated to different extents in Parkinson's disease (14, 44), some differences in the reaction upon blindfolding could be present.

The time series obtained are supposed to be stationary during the test period of two minutes. The logarithmized values of the standard deviation and the power spectral density of the time series are assumed to be approximately normally distributed.

MATERIAL

Normals.

89 healthy persons, for more detailed description see I.

Psychogenic Astasia abasia.

Number of cases: 17, 8 men and 9 women.

Median and range of age: 52, 31—64 years.

Height: 167, 162—188 cm.

Body weight: 65, 43—98 kg.

The patients were examined neurologically because of a seriously disabling disorder of balance. Neuropathology indicated by symptoms found in six patients was considered unable to account for the disorder of balance, which was manifested as bizarre postural movements of wide range when walking and standing. Psychiatric exploration suggested the seemingly unmotivated motor acts (performed when walking and standing) to be a tool for achievement of some advantage from the illness.

The following neuropathology was observed in six patients, namely: onesided vestibular areflexia in two patients — one of them had been operated on for a leftsided acoustic neurinoma — benign positional vertigo in one patient, congenital nystagmus in one patient, a discrete hemiparesis due to a previous vascular lesion in one patient and a moderate reduction of cutaneous and vibration sense in the legs due to myelopathy in one patient. Two patients had developed a disturbance of balance subsequently to head trauma and one of these patients refused to participate in the examination of "static" standing with eyes closed. Both were otoneurologically healthy.

Spinal ataxia

Number of cases: 11, 4 men and 7 women.

Median and range of age: 60, 17 — 80 years.

Height: 167, 152 — 183 cm.

Weight: 60, 50 — 91 kg.

Two patients suffered from tabes dorsalis. Joint sense and discriminatory cutaneous sense were markedly impaired in both legs. The vibration sense was lost. Both patients suffered from muscular hypotonia, one of the patients could be examined only once. Both patients displayed a positive Romberg's sign and could

thus not be examined for "static" standing with closed eyes. Two patients suffered from myelopathy due to B₁₂-vitamin deficiency. Polyneuropathy was of slight degree in both patients. The vibration sense was practically lost in the legs, kinesthesia was highly reduced together with some defect of the discriminatory cutaneous sense. A spastic paraparesis of moderate degree was present. The patients were unable to maintain "static" standing with the eyes closed. Another patient, suffering from B₁₂-vitamin deficiency, suffered from an extreme reduction of the vibration sense, while other sensory modalities were only slightly affected. The patient displayed slight disturbances of movements and Romberg's sign was negative.

In one patient, suffering from compression of the spinal cord, at the CV-CVII level, joint sense and vibration sense in the legs were highly reduced. There was a spastic paraparesis of slight — moderate degree. The patient was unable to maintain "static" standing with the eyes closed.

In another patient, suffering from cervical spondylosis, the sensibility to vibration and to small passive movements of the joints in the legs were markedly reduced. Voluntary movements of the legs were moderately disordered. Romberg's sign was not distinctly positive.

In one patient suffering from myelopathy of unknown etiology with a spastic paraparesis of low degree, the vibration sense was markedly affected in both legs. Kinaesthesia was only slightly disturbed. The gait was uncertain, Romberg's test was negative.

In one patient suffering from myelopathy of unknown etiology, the vibration sense and joint sense were highly reduced and there was a spastic paraparesis of low degree. The gait and stance were slightly uncertain. Romberg's test was not distinctly positive.

One patient, suffering from compression of the spinal cord due to a tumor at the C II — C III level, showed a very marked reduction of joint sense and vibration sense in the left leg, the vibration sense was in fact almost absent. In the right leg there was a slight spastic paresis. (There was a disturbance of cutaneous sensibility in the left hand.) Romberg's test was not distinctly positive.

Another patient suffered from a marked reduction of the vibration sense and of sensibility to passive movements in both legs together with a slight spastic paraparesis due to a midthoracic meningeoma. There was also some reduction of cutaneous sensibility in the lower extremities. Romberg's sign was not distinctly positive.

Cerebellar ataxia

Number of cases: 17, 13 men and 4 women.

Median and range of age: 58, 16 — 73 years.

Height: 169, 151 — 182 cm.

Weight: 63, 45 — 82 kg.

Five patients suffered from Cerebellar ataxia due to chronic alcoholism. They displayed unsteadiness of gait and stance. Voluntary movements of the legs were atactic while only a slight ataxia of voluntary movements of the arms was found. The patients had also moderately reduced tendon jerks due to polyneuropathy. Romberg's sign was negative.

Four patients suffered from cerebellopathy of unknown etiology. They displayed unsteadiness in walking and ataxia of the arms and legs, predominantly in the latter. In one patient the right arm and leg were more atactic than the extremities on the left. The patient also displayed a certain degree of anxiety. One of these patients was unable to maintain "static" standing in accordance with the test instruction after closure of the eyes.

One patient suffered from hereditary cerebellar ataxia associated with polyneuropathy. Cutaneous and to a certain degree proprioceptive sensibility were moderately reduced. Romberg's sign was not distinctly positive.

Three patients suffered from cerebellar ataxia due to multiple sclerosis. They also exhibited spastic paraparesis of moderate degree together with some reduction of the vibration sensation in the legs. In all cases there was bilateral dysmetria in both arms and legs together with unsteadiness of gait.

One patient suffered from Arnold-Chiari's malformation. The dominating symptom was unsteadiness of gait and he also exhibited a nystagmus. Sensory tests were normal.

One patient suffered from an extra-cerebellar tumor (cholesteatoma) with unsteadiness of gait as the dominant symptom.

One patient with a medulloblastoma displayed ataxia in the left arm and leg, hypotonia and absence of associated movements in the left arm. The patient was leaning slightly to the left when walking and standing.

One patient suffered from an intracerebellar tumor with hypotonia and ataxia in the left arm and leg.

Spastic paraparesis

Number of cases: 12, 2 men and 10 women.

Median and range of age: 53, 18 — 78 years.

Height: 166, 151 — 180 cm.

Weight: 68, 37 — 89 kg.

Two patients suffered from a spastic paraparesis, probably of hereditary origin.

Two patients suffered from a spastic paraparesis due to amyotrophic lateral sclerosis.

In one patient there was a moderate degree of spastic paresis in the left leg, due to a meningeoma at the C VII — C VIII level. No sensory defects were found.

One patient suffered from an acute myelopathy at a low thoracic level. There was a moderate degree of spasticity in both legs. Proprioception was intact but cutaneous sensibility to light touch and pin-prick was highly reduced in both legs.

One patient suffered from a slight-moderate spastic paraparesis of unknown etiology. Sensory tests were normal.

One patient suffered from a spastic paraparesis due to a spinal infarction at a midthoracic level. Cutaneous sensibility, touch and pin-prick, was slightly reduced below the umbilicus.

One patient suffered from spasticity in both legs. No sensory defects were found.

One patient suffered from a chronic myelopathy with a spastic paraparesis more on the right than on the left. No sensory defects were found.

One patient suffered from chronic myelopathy with a spastic paraparesis of moderate degree. The patient displayed uncertain gait and stance, no sensory defects were found.

One patient with an acute myelopathy manifested by a spastic paraparesis, more in the left leg than in the right. Sensory tests were normal.

Parkinson's disease.

Number of cases: 10, 6 men and 4 women.

Median and range of age: 55, 36 — 68 years.

Height: 168, 164 — 178 cm.

Weight: 64, 45 — 80 kg.

In six patients the right side of the body was most affected, in four patients the left side. In four patients thalamotomy had been performed previously. Rigidity was prominent in nine and extreme in one case. Tremor was slight in three, moderate in three, prominent in three and extreme in one case. The time needed for the patients to take off and put on their shoes was median 212 and range 44 — 670 seconds.

Cerebellum partially resected.

Number of cases: 8, 4 men och 4 women.

Median and range of age: 44,5. 21 — 64 years.

Height: 168, 161 — 178 cm.

Weight: 67, 61 — 92 kg.

Time lapsed between the operation and the test: Median 1,25.

Range 0,1 — 4,5 years.

According to the operation protocols the following lesions had been made.

1. Hemangioblastoma on the right side. Resection of moderate extension laterally of the right hemisphere.
2. Right sided meningeoma of tentorium cerebelli. A local compression of the right cerebellar hemisphere and of the brainstem was observed.
3. Hemangioma. The patient had been operated on once before. Resection of of most of the vermis, but for a small caudal part.
4. Astrocytoma cerebelli. Resection of most of the vermis and medial part of the right hemisphere.
5. Cyst of the right hemisphere. Resection of the right tonsilla and adjacent parts of the hemisphere.
6. Meningeoma of tentorium cerebelli. Resection of almost the whole right hemisphere.
7. Astrocytoma cerebelli. Resection of most of the left hemisphere and a small part of vermis.
8. Meningeoma of the IV ventricle. Resection of the most caudal part of the vermis.

No signs besides ataxia were found on a neurological examination, but for a mild spasticity in case 2, who had suffered a compression of the brain-stem.

Unilateral destruction of the labyrinth.

Number of cases: 7, 5 men and 2 women.

Median and range of age: 53, 42 — 64 years.

Height: 175, 161 — 184 cm.

Weight: 75, 64 — 82 kg.

Time lapse since the operation: Median 5 and range 1 — 8 years.

The operation had been performed according to Cawthorn's method (5,10), 4 on the right and 2 on the left side, because of Ménière's disease.

In a neurological examination no pathology was found but some of the patients reported the feeling of a slight insecurity of balance for some moments after very quick movements of the head.

METHODS

The times series from quasistationary standing in the patients were recorded and identified as described in I. In principle four test categories were performed, measurements of postural movements in the frontal and sagittal plane while standing with the eyes open and closed respectively. The result vectors consisted of 13 numbers, the standard deviation and the power spectral density of the time series, the latter described by 12 values, see I. Sample means and standard deviations of the vector components were displayed in tables and diagrams, the diagrams also containing sample means and standard deviations for the mean values and linear trends of the time series.

The effect of closure of the eyes upon the time series was supposed to be best illustrated by taking the difference between time series obtained during standing with the eyes open and closed for each individual.

The patients with a distinctly positive Romberg's sign, especially in the group spinal ataxia, were unable to stand according to the test instruction, when they had closed their eyes. This was the case also in a few other patients as described in Material.

Differences between mean values in different groups were compared with the sample standard deviation obtained in normals which was conceived as a reasonable norm.

Although the sample dispersions in different groups might not be exactly similar a step-wise linear discriminant analysis (60) was exploited in order to determine the additional information due to the spectral density. The standard program BMD07M was used. The standard deviations of the time series were studied at the first step. At a second step spectral density figures with coefficients significantly different from 0 at least at the 5% level were included. An F-matrix and a reclassification matrix were read off at these two steps. The results concerning time series of body movements in the frontal plane for the groups Cerebellum partially resected and Unilateral labyrinthic destruction had to be deleted because of a programming error, in the discriminant analysis.

RESULTS AND COMMENTS

Healthy subjects, groups of patients with Astasia abasia, Spinal ataxia and Cerebellar ataxia.

The body movements in the frontal and sagittal plane are of larger magnitude in the three patient groups than in healthy subjects. The mean values of the standard deviation of the time series are of the same order of magnitude in the patient groups. (Tables 1 and 3). Based upon the information furnished by the standard deviation of the time series, mainly differentiation between healthy subjects and people suffering from a disorder of balance is obtained. (Tables 5 — 10). Discrimination between the patient groups is attained when the spectral density is considered in addition, (Tables 5 — 10). The dynamic pattern of the oscillation in psychogenic Astasia abasia resembles that found in Normals by a great content of slow modes. In Spinal and Cerebellar ataxia there was a relatively greater content of frequencies in the interval 0.5 — 5.0 Hz. Cerebellar ataxia differs slightly from Spinal ataxia by a greater proportion of frequencies, about 0,5 Hz, especially with regard to oscillations in the frontal plane and an increase of fast oscillations at the upper end of the spectrum. (Tables 1 — 4). (Diagrams 8 — 19 in the appendix). In Spinal ataxia the increase of fast modes might follow from disconnection of the long loop Cerebral control, implying that the control system has to rely upon short circuit, fast although crude, spinal mechanisms (32, 45, 50). The divergent value at 0.75 Hz is probably due to a technical error. As shown by (Table 2) also the corresponding values for the difference in Cerebellar ataxia between standing with the eyes open and closed were influenced by the same error.

The difference between standing with the eyes open and closed is greater in Spinal ataxia than in the other groups, especially regarding measurements in the frontal plane.

Healthy subjects, Cerebellar ataxia and patients with Cerebellum partially resected.

The two patient groups are different with regard to the standard deviation of the time series. The frequency spectra are roughly accordant. (Tables 11 — 14 and 15 — 16). (Diagrams 16 — 23). They differ both rather distinctly from the normal group, by larger standard deviation and a greater content of fast modes. In the two patient groups the effect of closing the eyes is small, but for at certain points of the time series in the sagittal plane, roughly frequencies 0.75 — 1.75, in the second patient group (group 3). Figures at 0.75 Hz regarding oscillations in the frontal plane for Cerebellar ataxia (group 2) are aberrant, see above (Table 11). The results of a linear discriminant analysis (Tables 15 and 16) indicate no diffe-

rence between the patient groups concerning postural movements in the sagittal plane. The corresponding test of movements in the frontal plane was deleted, see Methods.

These findings validate previous results, since they suggest a possible specific pattern in Cerebellar ataxia.

Healthy subjects, Cerebellar ataxia (chronic alcoholism), and Cerebellar ataxia (due to other causes).

The two patient groups are in some accordance with each other. The aberrant values at about 0.75 Hz, see above concerning comments regarding the whole sample of Cerebellar ataxia, are found for Cerebellar ataxia due to alcoholism. Any local peak for frequencies at 3 Hz (66) was not observed. (Tables 17 — 20).

Noticeable is the small divergence between standing with the eyes open and closed in the frontal plane in the patient groups. Large differences are, however, found in the second patient group, regarding measurements in the sagittal plane, roughly being suggestive of an augmentation of the pattern found in Normals (Tables 17 — 20 and diagrams 24 — 31).

Healthy subjects, Unilateral labyrinthic destruction and patients with Cerebellum partially resected.

Unilateral labyrinthic destruction differs from Normals and the other patient group especially with regard to oscillations in the frontal plane by a small content of slow modes and a corresponding large proportion of fast oscillations. The standard deviation is greater than in Normals, in the frontal plane. In standing with the eyes closed the content of slow modes is further reduced and the content of fast oscillations is increased in unilat. lab. destruct. The standard deviation of the time series is almost unchanged both in the frontal and in the sagittal plane. (Tables 21 — 24).

Concerning the result in the other patient group see above and (Tables 21 — 24). The results from a linear discriminant analysis are shown in (Tables 25 — 28).

The results of a linear discriminant analysis between the Normal group and the group of patients with Unilateral labyrinthic destruction is shown in (Tables 25 and 26). Corresponding results for a discriminant analysis between the Normal group, the group of patients with Cerebellum partially resected and the group of patients with Unilateral labyrinthic destruction are shown in (Tables 27 and 28). See also (diagrams 20 — 23 and 32 — 35). The results of the linear discriminant analysis regarding values in the frontal plane with open eyes were deleted because of a programming error. See Methods

Healthy subjects, patients suffering from Parkinson's disease and Spastic paraparesis.

The body movements are of about the same order of magnitude in Parkinson's disease as in Normals. (Tables 29 — 32). The body movements are averagely larger in Spastic paraparesis. (Tables 29 — 32). In Parkinson's disease frequencies in the range 0 — 0.25 Hz are of great proportion. Most divergent from the pattern in the Normal group are low values for frequencies in the interval 0.5 — 1.5 Hz and a relatively large content of higher frequencies. This is supposed to correspond to the presence of rigidity and tremor respectively. While standing with the eyes closed the standard deviation of the time series is significantly larger than while standing with the eyes open in Parkinson's disease.

Contrary to expectation based upon findings in Normals, there is simultaneously an increase of frequencies in the interval 0 — 0.25 Hz and a reduction of fast modes. Thus, no sign of deteriorated control. This is supposed to support the assumption that the form of the spectral curve is to a substantial degree determined by damping associated with rigidity. In Spastic paraparesis the dynamic pattern of the postural oscillations is resembling that found in Healthy subjects. (Tables 29 — 32 and diagrams 40 — 43.). The dynamic pattern in Parkinson's disease is shown in (diagrams 36 — 39 of the appendix). The results of a discriminant analysis between healthy subjects and patients suffering from Parkinson's disease are shown in (Tables 33 and 34). In (Tables 35 and 36) the results of a discriminant analysis between healthy subjects, patients suffering from Parkinson's disease and patients suffering from Spastic paraparesis are shown.

The difference between standing with the eyes open and closed is unexpectedly large in Spastic paraparesis, at least with regard to some figures. It should further be observed that no significant differences between the Normal group and the group of patients suffering from paraparesis with regard to the difference between standing with the eyes open and closed respectively was revealed by a linear discriminant analysis. (Tables 35 and 36). In both patient groups, especially the Parkinsonism group, the standard deviation for a substantial number of variables was much larger than in the Normal group. In Parkinson's disease the complicated situation due to different degrees of tremor and rigidity might be an explanation.

The reclassification matrices presented, showing the results from linear discriminant analysis, reveal different degrees of overlapping. This reflects to some extent a heterogeneity of the patient groups, which is suggested by the description in Material. To some degree the heterogeneity might be explained by differences in personality, possibly augmented by interaction with the physiological deterioration.

Mean values for the mean, the linear trend and the standard deviation of the time series in the different patient groups are presented in angular units and distance of the position of the head (Tables 37 — 40). (Eq. 3 and 4 of I).

DISCUSSION

People suffering from a disorder of balance display instability in "static" standing manifested by a large magnitude of the body movements. The dynamic pattern of the movements is of some value for the discrimination between different disorders. Thus, people suffering from a psychogenic disorder display a great content of slow modes in the body oscillations compared with those suffering from ataxia. This indicates a lower energy content of the body movements in the former case, which would correspond to a better control of stability.

The most distinct effect of closure of the eyes was found in Spinal ataxia, concerning postural oscillations in the frontal plane. See (Tables 2, 4, 5—10). Together with the finding of a somewhat more specific pattern for Spinal ataxia with regard to postural oscillations in the frontal plane, this observation means a certain validation of the assumption that proprioceptive factors take a more integral part with regard to stabilization in the frontal than in the sagittal plane in quasistationary standing, (I).

A great difference between "static" standing with the eyes open and closed respectively in Spinal ataxia seems to be the most characteristic divergence from Cerebellar ataxia. It should be noticed that the difference in Spinal ataxia observed only concerns the dynamic pattern, which probably is a consequence of the fact that cases displaying a marked positive Romberg's sign had to be eliminated since they were unable to fulfil the demands of the test instruction.

The fact that cerebellar ataxia semiologically identified and the group of patients some time previously subjected to a partial resection of the cerebellum show small differences indicated a certain validation of the results.

Patients previously subjected to a unilateral labyrinthic destruction display some abnormality in "static" standing implying that the vestibular afferents are a relevant factor for postural control in "static" standing, which has been questioned by Walsh and Martin (71, 44).

Estimation of the dynamic pattern seems to be essential for recognition of characteristic features in Parkinson's disease. A comparatively great proportion of frequencies in the range 0 - 0.25 Hz and a small content of faster modes would correspond to the presence of rigidity. An increased content of frequencies above approximately 2 Hz due to tremor is in this context rather a methodological equivocation. The relative lack of signs of damping in spasticity is consistent with the *a priori* assumptions.

Tables III

Standard deviations are placed in brackets below corresponding mean values. In the F-matrices and the reclassifications the results obtained at the first step are placed in brackets.

FRONTAL PLANE OPEN EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal (1) N = 89	.106 (.179)	-.463 (.102)	-.382 (.068)	-1.036 (.255)	-1.405 (.382)	-1.743 (.634)	-2.026 (.613)	-2.356 (.597)	-2.550 (.566)	-2.568 (.409)	-2.731 (.588)	-3.127 (.863)	-2.543 (.324)
Astas abasia (2) N = 16	.399 (.328)	-.447 (.121)	-.348 (.049)	-1.114 (.357)	-1.713 (.400)	-2.026 (.381)	-2.291 (.446)	-2.475 (.445)	-2.637 (.435)	-2.704 (.368)	-2.837 (.403)	-3.045 (.431)	-2.571 (.539)
Spin ataxia (3) N = 11	.521 (.315)	-.503 (.166)	-.429 (.144)	-1.177 (.344)	-1.531 (.490)	-1.708 (.511)	-1.939 (.558)	-2.140 (.565)	-2.265 (.616)	-2.236 (.661)	-2.439 (.648)	-2.584 (.610)	-2.014 (.631)
Cereb ataxia (4) N = 16	.455 (.243)	-.492 (.142)	-.385 (.101)	-.993 (.170)	-1.829 (1.307)	-1.913 (.380)	-2.180 (.474)	-2.307 (.418)	-2.386 (.431)	-2.392 (.404)	-2.509 (.404)	-2.710 (.421)	-1.992 (.450)
t values for mean value differences													
1 - 2	-18.714	-1.365	-3.316	2.020	5.349	2.961	2.868	1.322	1.019	2.206	1.196	-.622	.227
2 - 3	-23.234	2.276	4.585	3.668	2.188	-.366	-.942	-2.400	-3.340	-3.763	-3.293	-4.173	-4.283
1 - 4	-20.785	1.560	.292	-1.119	7.362	1.778	1.666	-.545	-1.922	-2.855	-2.500	-3.205	-4.461
2 - 3	-4.521	3.641	7.901	1.648	-3.160	-3.327	-3.808	-3.722	-4.358	-5.968	-4.491	-3.551	-4.510
2 - 4	-2.071	2.926	3.609	-3.139	-2.014	-1.182	-2.830	-1.859	-2.046	-5.060	-3.104	-3.827	-4.688
3 - 4	2.463	-.715	-4.293	-4.786	5.175	2.145	2.607	1.855	1.418	.908	.789	.969	.178

Table 1

Mean values, standard deviations (in brackets) and t-values of time series data in Normals, Astasia abasia, Spinal ataxia and Cerebellar ataxia.

Table 2

FRONTAL PLANE OPEN-CLOSED EYES

Clin state	Stand dev													2.75—	
		0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	5.00		
Normal N = 55	-.110 (.153)	.021 (.119)	.002 (.063)	-.025 (.238)	.000 (.310)	.032 (.400)	.042 (.657)	.006 (.652)	-.009 (.354)	.043 (.382)	.020 (.610)	.025 (.884)	.129 (.968)		
Astas abasia N = 15	-.063 (.191)	.086 (.168)	.037 (.071)	-.205 (.343)	-.300 (.462)	-.184 (.401)	-.163 (.449)	-.133 (.465)	-.107 (.547)	.113 (1.095)	.047 (.682)	.366 (1.179)	.353 (.941)		
Spin ataxia N = 6	-.081 (.378)	.089 (.108)	.013 (.148)	-.413 (.511)	-.578 (.617)	-.402 (.705)	-.330 (.717)	-.337 (.635)	-.320 (.680)	-.320 (.737)	-.278 (.691)	-.225 (.570)	-.086 (.545)		
Cereb ataxia N = 14	-.067 (.187)	.004 (.130)	-.011 (.076)	-.036 (.194)	-.354 (1.124)	-.041 (.324)	-.009 (.316)	-.026 (.271)	.030 (.315)	.096 (.324)	.101 (.340)	.051 (.401)	.148 (.441)		
values for mean value differences															
1	-5.283	1.297	.233	-.772	.000	.586	.470	.067	-.186	.827	.241	.208	.979		
2	-3.026	5.311	4.316	6.330	-7.111	-3.381	-1.823	-1.499	-2.222	2.174	.566	3.042	2.679		
3	-3.890	5.496	1.516	-12.751	-13.702	-7.385	-3.691	-3.798	-6.643	-6.146	-3.349	-1.816	-.653		
4	-3.218	.467	-1.283	-1.111	-8.392	-.753	-.101	-.293	.622	1.847	1.217	.424	1.124		

Mean values, standard deviations (in brackets) and t-values for differences between standing with the eyes open and closed in Normals, Astasia abasia, Spinal ataxia and Cerebellar ataxia.

SAGITTAL PLANE OPEN EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal (1) N = 60	.161 (.182)	-.401 (.071)	-.345 (.035)	-1.330 (.751)	-1.696 (.379)	-1.909 (.377)	-2.143 (.410)	-2.411 (.437)	-2.699 (.655)	-2.818 (.654)	-3.000 (.673)	-3.373 (.911)	-3.001 (1.115)
Astasia abasia (2) N = 17	.508 (.324)	-.453 (.109)	-.346 (.040)	-1.080 (.383)	-1.735 (.506)	-2.015 (.347)	-2.300 (.407)	-2.490 (.426)	-2.722 (.495)	-2.815 (.452)	-2.927 (.475)	-3.208 (.966)	-2.607 (.904)
Spin ataxia (3) N = 10	.454 (.171)	-.553 (.127)	-.449 (.086)	-.983 (.182)	-1.262 (.258)	-1.454 (.317)	-1.651 (.411)	-1.878 (.448)	-2.041 (.445)	-2.097 (.432)	-2.234 (.417)	-2.480 (.496)	-2.019 (.732)
Cereb ataxia (4) N = 17	.483 (.182)	-.528 (.115)	-.411 (.082)	-.938 (.168)	-1.358 (.308)	-1.633 (.344)	-1.845 (.294)	-2.080 (.333)	-2.242 (.319)	-2.320 (.320)	-2.415 (.367)	-2.551 (.498)	-1.944 (.518)
F values for mean value differences													
1—2	-10.356	3.977	.155	-1.808	.559	1.527	2.079	.982	.190	-.025	-.589	-.984	-1.919
1—3	-8.744	11.628	16.139	-2.510	-6.131	-6.555	-6.518	-6.624	-5.456	-5.982	-6.182	-5.324	-4.784
1—4	-9.609	9.715	10.242	-2.835	-4.844	-3.976	-3.948	-4.114	-3.789	-4.136	-4.721	-4.900	-5.149
2—3	1.611	7.649	15.982	-.702	-6.691	-8.083	-8.597	-7.607	-5.646	-5.963	-5.593	-4.340	-2.864
2—4	.746	5.738	10.087	-1.027	-5.402	-5.647	-6.028	-5.096	-3.980	-4.111	-4.132	-3.917	-3.230
3—4	-.866	-1.913	-5.897	-.325	1.287	2.579	2.570	2.511	1.667	1.864	1.461	.423	-.365

Table 3

Mean values, standard deviations (in brackets) and t-values of time series data in Normals, Astasia abasia, Spinal ataxia and Cerebellar ataxia.

SAGITTAL PLANE OPEN-CLOSED EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal (1) N = 43	-.059 (.146)	.067 (.199)	.031 (.056)	-.330 (.922)	-.230 (.409)	-.233 (.419)	-.227 (.418)	-.218 (.442)	-.276 (.691)	-.226 (.708)	-.198 (.755)	-.230 (1.334)	-.387 (1.499)
Astas abasia (2) N = 16	-.089 (.179)	.073 (.136)	.045 (.064)	-.108 (.403)	-.181 (.603)	-.176 (.450)	-.205 (.481)	-.206 (.460)	-.221 (.540)	-.218 (.551)	-.202 (.522)	-.308 (.923)	-.026 (1.168)
Spin ataxia (3) N = 5	-.131 (.166)	.142 (.103)	.050 (.032)	-.238 (.128)	-.232 (.115)	-.258 (.113)	-.354 (.250)	-.358 (.272)	-.270 (.129)	-.196 (.118)	-.200 (.064)	-.330 (.226)	-.509 (.680)
Cereb ataxia (4) N = 15	-.166 (.224)	.065 (.141)	.051 (.095)	-.014 (.284)	-.143 (.388)	-.117 (.357)	-.096 (.335)	-.156 (.367)	-.161 (.355)	-.109 (.366)	-.067 (.381)	-.080 (.358)	-.116 (.327)
t values for mean value differences													
1	-2.619	2.182	3.588	-2.320	-3.645	-3.603	-3.519	-3.196	-2.588	-2.069	-1.670	-1.161	-1.635
2	-3.950	2.377	5.207	-.759	-2.868	-2.722	-3.178	-3.020	-2.072	-1.995	-1.733	-1.496	-.113
3	-5.815	4.624	5.789	-1.673	-3.676	-3.991	-5.448	-5.249	-2.532	-1.794	-1.717	-1.603	-2.201
4	-7.368	2.117	5.902	-.099	-2.266	-1.810	-1.448	-2.287	-1.510	-1.998	-.575	-.388	-.201

Table 4 Mean values, standard deviations (in brackets) and t-values for differences between standing with the eyes open and closed in Normals, Astasia absia, Spinal ataxia and Cerebellar ataxia.

Test category	Clinical state 	Astasia abasia	Spinal ataxia	Df.
Front. plane open eyes	Normal	24.16 (72.21)	33.55 (80.34)	5/109 (1/113)
—''—	Astasia abasia	—	4.16 (2.02)	—
Var. in eq.	St. dev.	0.00Hz 0.50Hz 0.75Hz 2.00Hz	(St. dev.)	
Front. plane open-cl. eyes	Normal	2.94 (0.78)	8.17 (0.13)	2/72 (1/73)
—''—	Astasia abasia	—	2.65 (0.04)	—
Var. in eq.	St. dev.	0.75Hz (St. dev.)		
Sagitt. plane open eyes	Normal	16.97 (34.43)	23.54 (15.91)	4/81 (1/84)
—''—	Astasia abasia	—	13.92 (0.39)	—
Var. in eq.	St. dev.	0.00Hz 0.25Hz 2.75Hz	(St. dev.)	

Table 5 F-matrix from a linear discriminant analysis.
Groups studied: Normal, Astasia abasia, Spinal ataxia.
Results based upon the standard deviation of the time series are in brackets.

Test category	Original classification	Re-classified as		
	Clinical state ↗	Normal	Astasia abasia	Spinal ataxia
Frontal plane open eyes	Normal	85 (83)	4 (6)	0 (0)
—''—	Astasia abasia	3 (4)	10 (5)	3 (7)
—''—	Spinal ataxia	0 (1)	3 (5)	8 (5)
Frontal plane open-cl. eyes	Normal	39 (27)	11 (23)	5 (5)
—''—	Astasia abasia	8 (7)	3 (7)	4 (1)
—''—	Spinal ataxia	1 (4)	1 (2)	4 (0)
Sagittal plane open eyes	Normal	59 (44)	0 (0)	1 (16)
—''—	Astasia abasia	4 (4)	12 (9)	1 (4)
—''—	Spinal ataxia	3 (2)	1 (6)	6 (2)

Table 6 Re-classification matrix from a linear discriminant analysis.
Groups studied: Normal, Astasia abasia, Spinal ataxia.
Results based upon the standard deviation of the time series are in brackets.

Test category	Clinical state ↗	Astasia abasia	Cerebellar ataxia	Df.
Frontal plane open eyes	Normal	24.14 (76.89)	46.82 (94.83)	4/115 (1/118)
—''—	Astasia abasia	—	4.05 (0.55)	—
Var. in eq.	St. dev.	0.50Hz 0.755z 2.00Hz	(St. dev.)	
Sagittal plane open eyes	Normal	17.32 (34.94)	26.41 (30.14)	4/38 (1/91)
—''—	Astasia abasia	—	5.05 (0.11)	—
Var. in eq.	St. dev.	0.00Hz 0.25Hz 2.75Hz	(St. dev.)	

Table 7 F-matrix of mean value differences from a linear discriminant analysis. Groups studied: Normal, Astasia abasia, Cerebellar ataxia. Results based upon the standard deviation of the time series are in brackets.

Test category	Original classification	Re-classified as		
	Clinical state ↗	Normal	Astasia abasia	Cerebellar ataxia
Frontal plane open eyes	Normal	85 (83)	4 (6)	0 (0)
—''—	Astasia abasia	3 (4)	7 (5)	6 (7)
—''—	Cerebellar ataxia	0 (2)	5 (7)	11 (7)
Sagittal plane open eyes	Normal	59 (46)	0 (0)	1 (14)
—''—	Astasia abasia	4 (5)	12 (9)	1 (3)
—''—	Cerebellar ataxia	0 (3)	5 (6)	12 (8)

Table 8 Re-classification from a linear discriminant analysis. Groups studied: Normal, Astasia abasia, Cerebellar ataxia. Results based upon the standard deviation of the time series are in brackets.

Test category	Clinical state ↗	Spinal ataxia	Cerebellar ataxia	Df.
Frontal plane open eyes	Normal	44.94 (92.78)	57.24 (102.86)	4/110 (1/113)
—''—	Spinal ataxia	—	2.71 (0.69)	—
Var. in eq.	Stand.dev.	0.50Hz 0.75Hz	2.00Hz (St. dev.)	
Frontal plane open-cl. eyes	Normal	7.03 (0.14)	0.42 (0.62)	2/71 (1/72)
—''—	Spinal ataxia	—	4.50 (0.03)	—
Var. in eq.	Stand.dev.	0.50Hz (St. dev.)		
Sagittal plane open eyes	Normal	18.91 (22.58)	34.51 (42.14)	4/81 (1/84)
—''—	Spinal ataxia	—	2.23 (0.16)	—
Var. in eq.	Stand.dev.	0.00Hz 0.25Hz	2.75Hz (St. dev.)	

Table 9 F-matrix of mean value differences from a linear discriminant analysis. Groups studied: Normal, Spinal ataxia, Cerebellar ataxia. Results based upon the standard deviation of the time series are in brackets.

Test category	Original classification	Re-classified as		
	Clinical state ↗	Normal	Spinal ataxia	Cerebellar ataxia
Frontal plane open eyes	Normal	87 (83)	0 (0)	2 (6)
—''—	Spinal ataxia	0 (1)	7 (5)	4 (5)
—''—	Cerebellar ataxia	0 (2)	2 (7)	14 (7)
Frontal plane open-cl. eyes	Normal	26 (27)	10 (4)	19 (24)
—''—	Spinal ataxia	2 (4)	3 (0)	1 (2)
—''—	Cerebellar ataxia	5 (5)	3 (0)	6 (9)
Sagittal plane open eyes	Normal	60 (44)	0 (16)	0 (0)
—''—	Spinal ataxia	3 (2)	6 (2)	1 (6)
—''—	Cerebellar ataxia	0 (3)	3 (6)	14 (8)

Table 10

Re-classification from a linear discriminant analysis.

Groups studied: Normal, Spinal ataxia, Cerebellar ataxia. Results based upon the standard deviation of the time series are in brackets.

FRONTAL PLANE OPEN EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal (1) N = 89	-.106 (.179)	-.468 (.102)	-.382 (.068)	-1.036 (.255)	-1.405 (.382)	-1.743 (.634)	-2.026 (.613)	-2.356 (.597)	-2.550 (.566)	-2.568 (.409)	-2.731 (.588)	-3.127 (.863)	-2.543 (.824)
Cereb ataxia N = 16 (2)	.455 (.243)	-.492 (.142)	-.385 (.101)	-.993 (.170)	-1.829 (1.307)	-1.913 (.380)	-2.180 (.474)	-2.307 (.418)	-2.386 (.431)	-2.392 (.404)	-2.509 (.404)	-2.710 (.421)	-1.992 (.450)
Cereb part resect N = 8 (7)	.082 (.137)	-.504 (.128)	-.392 (.064)	-.984 (.288)	-1.432 (.304)	-1.752 (.320)	-2.008 (.352)	-2.328 (.400)	-2.392 (.448)	-2.280 (.576)	-2.360 (.592)	-2.872 (.608)	-2.260 (.715)
t values for mean value differences													
1 - 2	-20.785	1.560	.292	-1.119	7.362	1.779	1.666	-.545	-1.922	-2.855	-2.505	-3.205	-4.436
1 - 3	-7.049	2.340	.974	-1.352	.468	.093	-.182	-.312	-1.853	-5.643	-4.186	-1.953	-2.279
2 - 3	13.820	.780	.682	-.234	-6.892	1.685	-1.848	-.233	.070	-2.788	-1.680	1.245	2.157

Table 11

Mean values, standard deviations (in brackets) and t-values of the time series data in Normals, Cerebellar ataxia, Cerebellum part. resected.

FRONTAL PLANE OPEN-CLOSED EYES														
Clin state	Stand		0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
	dev													
Normal (1) N = 55	-.110 (.153)	.021 (.119)	.002 (.063)	-.025 (.238)	.000 (.310)	.032 (.400)	.042 (.657)	.006 (.652)	-.009 (.354)	.043 (.382)	.020 (.610)	.025 (.884)	.129 (.968)	
Cereb ataxia N = 14 (2)	-.067 (.187)	.004 (.130)	-.011 (.076)	-.036 (.194)	-.354 (1.124)	-.041 (.324)	-.009 (.316)	-.026 (.271)	.030 (.315)	.096 (.324)	.101 (.340)	.051 (.401)	.148 (.441)	
Cereb part resect N = 8 (3)	-.069 (.182)	.044 (.085)	-.004 (.032)	-.163 (.290)	-.028 (.316)	.001 (.231)	-.039 (.246)	-.174 (.180)	-.093 (.199)	.049 (.342)	.056 (.364)	-.031 (.316)	.279 (.792)	
t values for mean value differences														
1	-5.283	1.297	.233	-.772	.000	.586	.470	.067	-.186	.827	.241	.208	.979	
2	-3.218	.247	-1.283	-1.111	-8.392	-.753	-.101	-.293	.622	1.847	1.217	.424	1.124	
3	-2.786	3.804	-.919	5.033	-.664	.018	-.436	-1.961	.939	.042	.675	-.258	2.118	

Table 12 Mena values, standard deviations (in brackets) and t-values for differences between standing with the eyes open and closed in Normals, Cerebellar ataxia and Cerebellum part. resected.

SAGITTAL PLANE OPEN EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal (1) N=60	.161 (.182)	-.401 (.071)	-.345 (.035)	-1.330 (.751)	-1.696 (.379)	-1.909 (.377)	-2.143 (.410)	-2.411 (.437)	-2.699 (.655)	-2.818 (.654)	-3.000 (.673)	-3.373 (.911)	-3.001 (1.115)
Cereb ataxia N=17 (2)	.483 (.182)	-.528 (.115)	-.411 (.082)	-.938 (.168)	-1.358 (.308)	-1.633 (.344)	-1.845 (.294)	-2.080 (.333)	-2.242 (.319)	-2.320 (.320)	-2.415 (.367)	-2.551 (.498)	-1.944 (.518)
Cereb part resect N=8 (3)	.334 (.75)	-.453 (.062)	-.360 (.041)	-1.000 (.135)	-1.538 (.213)	-1.878 (.322)	-2.197 (.350)	-2.460 (.296)	-2.585 (.264)	-2.545 (.291)	-2.665 (.311)	-3.012 (.431)	-2.351 (.531)
t values for mean value differences													
1 — 2	-9.609	9.715	10.242	-2.835	-4.844	-3.976	-3.948	-4.114	-3.789	-4.136	-4.721	-4.942	-5.149
1 — 3	-5.162	3.978	2.327	-2.387	-2.179	-.446	.715	.609	.945	-2.265	-2.703	-2.152	-3.166
2 — 3	4.411	-5.738	-7.914	.448	2.578	3.530	4.663	4.723	2.844	1.868	2.018	2.749	1.982

Table 13

Mean values, standard deviations (in brackets) and t-values of time series data in Normals, Cerebellar ataxia and Cerebellum part. resected.

SAGITTAL PLANE OPEN-CLOSED EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal (1) N=43	-.059 (.146)	.067 (.199)	.031 (.056)	-.330 (.922)	-.230 (.409)	-.233 (.419)	-.227 (.418)	-.218 (.442)	-.276 (.691)	-.226 (.708)	-.198 (.755)	-.230 (1.334)	-.378 (1.499)
Cereb ataxia N=15 (2)	-.166 (.224)	.065 (.141)	.051 (.095)	-.014 (.284)	-.143 (.388)	-.117 (.357)	-.096 (.335)	-.156 (.367)	-.161 (.355)	-.109 (.366)	-.067 (.381)	-.080 (.358)	-.116 (.327)
Cereb part resect N=8 (3)	-.050 (.076)	.105 (.092)	.065 (.055)	-.126 (.164)	-.279 (.289)	-.345 (.383)	-.444 (.410)	-.458 (.360)	-.351 (.377)	-.194 (.405)	-.126 (.393)	-.185 (.402)	-.264 (.531)
t values for mean value differences													
1	-2.619	2.182	3.588	-2.320	-3.645	-3.603	-3.519	-3.196	-2.588	-2.069	-1.670	-1.161	-1.635
2	-7.368	2.117	5.902	-.989	-2.266	-1.810	-1.488	-2.287	-1.510	-.998	-.575	-.388	-.501
3	-1.331	3.420	7.522	-.886	-4.421	-5.336	-6.884	-6.716	-3.292	-1.776	-1.081	-.898	-1.141

Table 14

Mean values, standard deviations (in brackets) and t-values for differences between standing with the eyes open and closed in Normals, Cerebellar ataxia and Cerebellum part. resected.

Test category	Clinical state	Cerebellar ataxia	Cerebellum part. resect.	
Sagittal plane open eyes	Normal	29.22 (28.16)	23.15 (20.32)	3/80 (1/82)
—''—	Cerebellar ataxia	—	0.76 (0.31)	—
Var. in eq.	St. dev.	0.00Hz 0.25Hz	(St. dev.)	

Table 15 F-matrix of mean value differences from a linear discriminant analysis. Groups studied: Normal, Cerebellar ataxia, Cerebellum part. resect. Results based upon the standard deviation of the time series are in brackets.

Test category	Original classification	Re-classified as		
	Clinical state	Normal	Cerebellar ataxia	Cerebellum part. resect.
Sagittal plane open eyes	Normal	60 (43)	0 (16)	0 (1)
—''—	Cerebellar ataxia	2 (4)	9 (6)	6 (7)
—''—	Cerebellum part. resect.	0 (1)	4 (4)	4 (3)

Table 16 Re-classification from a linear discriminant analysis. Groups studied: Normal, Cerebellar ataxia, Cerebellum part. resect. Results based upon the standard deviation of the time series are in brackets.

FRONTAL PLANE OPEN EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal (1) N = 89	.106 (.179)	-.468 (.102)	-.382 (.068)	-1.036 (.255)	-1.405 (.382)	-1.743 (.634)	-2.026 (.613)	-2.356 (.597)	-2.550 (.566)	-2.568 (.409)	-2.731 (.588)	-3.127 (.863)	-2.543 (.824)
Cereb atax pers non alc N = 11 (2)	.481 (.265)	-.504 (.160)	-.401 (.128)	-.942 (.160)	-1.459 (.288)	-1.736 (.336)	-2.008 (.352)	-2.200 (.384)	-2.356 (.384)	-2.392 (.368)	-2.520 (.384)	-2.728 (.416)	-2.010 (.391)
Cereb atax alc N = 5 (3)	.400 (.202)	-.460 (.160)	-.372 (.100)	-1.080 (.180)	-2.660 (2.200)	-2.200 (.320)	-2.400 (.600)	-2.540 (.460)	-2.540 (.560)	-2.380 (.560)	-2.340 (.520)	-2.680 (.520)	-1.940 (.610)
t values for mean value differences													
1 - 2	-21.712	2.341	1.853	-2.444	.837	-.073	-.194	-1.732	-2.273	-2.854	-2.380	-3.066	-4.290
1 - 3	-18.711	-.517	-.981	-.975	26.214	18.210	4.112	2.044	-.117	-3.048	-4.409	-3.434	-4.853
2 - 3	3.001	-2.858	-2.834	1.469	25.377	18.137	4.306	3.778	2.156	-.194	-2.030	-.368	-.563

Table 17

Mena values, standard deviations (in brackets) and t-values of the time series data in Normals, Cerebellar ataxia pers non alc and Cerebellar ataxia alc.

FRONTAL PLANE OPEN-CLOSED EYES													
Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal (1) N = 55	-.110 (.153)	.021 (.119)	.002 (.063)	-.025 (.238)	.000 (.310)	.032 (.400)	.042 (.657)	.006 (.652)	-.009 (.354)	.043 (.382)	.020 (.610)	.025 (.884)	.129 (.968)
Cereb atax pers non alc N = 9	-.056 (.203)	.006 (.136)	-.010 (.074)	-.064 (.221)	-.010 (.360)	.037 (.375)	-.006 (.326)	.011 (.289)	.073 (.306)	.113 (.299)	.116 (.313)	.111 (.366)	.263 (.405)
Cereb atax alc N = 5	-.085 (.174)	-.000 (.134)	-.014 (.088)	-.126 (.146)	-1.008 (1.737)	-.182 (.141)	-.016 (.334)	-.092 (.252)	-.048 (.351)	.064 (.400)	.076 (.423)	-.058 (.481)	-.058 (.472)
t values for mean value differences													
1	-5.283	1.297	.233	-.771	.000	.538	.470	.067	-.186	.827	.241	.208	.979
2	-2.689	.344	-1.166	-1.976	.237	.680	-.067	.124	1.515	2.174	1.397	.922	1.997
3	-4.082	-.000	-1.633	-3.890	-23.895	-3.343	-.179	-1.036	-.997	1.231	.916	-.483	-.440

Table 18

Mean values, standard deviations (in brackets) and t-values for differences between standing with the eyes open and closed in Normals, Cerebellar ataxia pers non alc and Cerebellar ataxia alc.

SAGITTAL PLANE OPEN EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal N = 60 (1)	.161 (.182)	-.401 (.071)	-.345 (.035)	-1.330 (.751)	-1.696 (.379)	-1.909 (.377)	-2.143 (.410)	-2.411 (.437)	-2.699 (.655)	-2.818 (.654)	-3.000 (.673)	-3.373 (.911)	-3.001 (1.115)
Cereb atax pers non alc (2)	.507 (.210)	-.532 (.117)	-.408 (.075)	-.901 (.162)	-1.299 (.312)	-1.601 (.391)	-1.827 (.348)	-2.094 (.383)	-2.281 (.347)	-2.374 (.317)	-2.492 (.323)	-2.676 (.358)	-2.067 (.410)
Cereb atax alc (3)	.426 (.066)	-.519 (.122)	-.420 (.106)	-1.026 (.165)	-1.498 (.277)	-1.710 (.203)	-1.888 (.101)	-2.048 (.195)	-2.150 (.246)	-2.190 (.320)	-2.230 (.438)	-2.250 (.693)	-1.648 (.661)
t values for mean value differences													
1 - 2	-10.413	10.106	9.859	-3.129	-5.737	-4.475	-4.222	-3.973	-3.495	-3.735	-4.134	-4.141	-4.588
1 - 3	-7.975	9.103	11.737	-2.224	-2.861	-2.891	-3.407	-4.550	-4.591	-5.260	-6.267	-6.752	-6.646
2 - 3	2.438	-1.003	1.878	.912	2.876	1.584	.815	.702	-1.095	-1.541	-2.132	-2.561	-2.058

Table 19 Mean values, standard deviations (in brackets) and t-values of time series data in Normals, Cerebellar ataxia pers non alc and Cerebellar ataxia alc.

Table 20

SAGITTAL PLANE OPEN-CLOSED EYES													
Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal N=43 (1)	-.059 (.146)	.067 (.199)	.031 (.056)	-.330 (.922)	-.230 (.409)	-.233 (.419)	-.227 (.418)	-.218 (.442)	-.276 (.691)	-.226 (.708)	-.198 (.755)	-.230 (1.334)	-.378 (1.499)
Cereb atax pers non alc N=10 (2)	-.167 (.252)	.011 (.102)	.007 (.047)	.027 (.319)	-.025 (.384)	-.037 (.398)	-.043 (.388)	-.102 (.438)	-.106 (.425)	-.044 (.433)	.010 (.438)	.027 (.391)	-.003 (.337)
Cereb atax alc N=5 (3)	-.165 (.183)	.174 (.156)	.140 (.110)	-.096 (.205)	-.378 (.301)	-.276 (.208)	-.202 (.182)	-.264 (.134)	-.272 (.107)	-.238 (.124)	-.222 (.182)	-.294 (.139)	-.343 (.153)
values for mean value differences													
1	-2.619	2.182	3.588	-2.320	-3.645	-3.603	-3.219	-3.196	-2.588	-2.069	-1.670	-1.161	-1.635
2	-7.413	.358	.810	.190	-.396	-.572	-.667	-1.495	-.994	-.403	.086	.131	-.013
3	-7.324	5.667	16.202	-.675	-5.989	-4.268	-3.132	-3.871	-2.551	-2.178	-1.905	-1.428	-1.482

Mean values, standard deviations (in brackets) and t-values for differences between standing with the eyes open and closed in Normals, Cerebellar ataxia pers non alc and Cerebellar ataxia alc.

FRONTAL PLANE OPEN EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal (1) N = 89	.106 (.179)	-.468 (.102)	-.382 (.068)	-1.036 (.255)	-1.405 (.382)	-1.743 (.634)	-2.026 (.613)	-2.356 (.597)	-2.550 (.566)	-2.568 (.409)	-2.731 (.588)	-3.127 (.863)	-2.543 (.321)
Cereb part resect N = 8 (2)	.082 (.137)	-.504 (.128)	-.392 (.064)	-.984 (.288)	-1.432 (.304)	-1.752 (.320)	-2.008 (.352)	-2.328 (.400)	-2.392 (.448)	-2.280 (.576)	-2.360 (.592)	-2.872 (.608)	-2.260 (.715)
Unilat lab destruct N = 7 (3)	.068 (.232)	-.602 (.200)	-.480 (.110)	-.930 (.280)	-1.200 (.380)	-1.480 (.326)	-1.790 (.304)	-2.080 (.270)	-2.180 (.244)	-2.100 (.280)	-2.180 (.320)	-2.500 (.363)	-1.780 (.562)

t values for mean value differences

1 - 2	-7.049	2.340	.974	-1.352	.468	.093	-.182	-.312	-1.853	-5.643	-4.186	-1.953	-2.279
1 - 3	-6.447	8.713	9.557	-2.549	-3.559	-2.751	-2.553	-3.066	-4.335	-7.589	-6.215	-4.818	-6.141
2 - 3	.518	6.372	8.582	1.196	-4.027	-2.861	-1.695	-2.753	-2.482	-1.847	-2.030	-2.865	-3.862

Table 21

Mean values, standard deviations (in brackets) and t-values for mean value differences data in Normals, Cerebellum partially resected and Unilateral labyrinthic destruction.

FRONTAL PLANE OPEN-CLOSED EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal N = 55 (1)	-.110 (.153)	.021 (.119)	.002 (.063)	.025 (.238)	.000 (.310)	.032 (.400)	.042 (.657)	.006 (.652)	-.009 (.354)	.043 (.382)	.020 (.610)	.025 (.884)	.129 (.968)
Cereb part resect N = 8 (2)	-.069 (.182)	.044 (.085)	-.004 (.032)	-.163 (.290)	-.028 (.316)	.001 (.231)	-.039 (.246)	-.174 (.180)	-.093 (.199)	.049 (.342)	.056 (.364)	-.031 (.316)	.279 (.792)
Unilat lab destruct N = 7 (3)	.002 (.156)	.137 (.200)	.073 (.115)	-.033 (.178)	.011 (.108)	.006 (.194)	-.126 (.292)	-.201 (.251)	-.161 (.231)	-.070 (.324)	-.070 (.325)	-.127 (.253)	-.204 (.386)
1	-5.283	1.297	.233	-.772	.000	.586	.470	.067	-.186	.827	.241	.208	.979
2	-2.786	3.804	-.919	-5.033	-.664	.018	-.436	-1.961	-.939	.942	.675	-.258	-2.118
3	.096	8.460	8.515	-1.020	.261	.110	-1.409	-2.037	-3.342	-1.347	-.843	-1.053	-1.549

Table 22

Mean value, standard deviations (in brackets) and t-values for mean differences between standing with the eyes open and closed in Normals, Cerebellum partially resected and Unilateral labyrinthine destruction.

SAGITTAL PLANE OPEN EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal N = 60 (1)	.161 (.182)	-.401 (.071)	-.345 (.035)	-1.330 (.751)	-1.696 (.379)	-1.909 (.377)	-2.143 (.410)	-2.411 (.437)	-2.699 (.655)	-2.818 (.654)	-3.000 (.673)	-3.373 (.911)	-3.001 (1.115)
Cereb part resect N = 8 (2)	.334 (.075)	-.453 (.062)	-.360 (.041)	-1.000 (.135)	-1.538 (.213)	-1.878 (.322)	-2.197 (.350)	-2.460 (.296)	-2.585 (.264)	-2.545 (.291)	-2.665 (.311)	-3.012 (.341)	-2.351 (.531)
Unilat lab destruct N = 7 (3)	.126 (.205)	-.515 (.130)	-.392 (.055)	-.972 (.277)	-1.394 (.236)	-1.645 (.277)	-1.821 (.325)	-2.061 (.389)	-2.225 (.406)	-2.265 (.413)	-2.399 (.392)	-2.774 (.363)	-2.218 (.414)
1 - 2	-5.162	3.978	2.327	-2.387	-2.179	-.446	.715	.609	-.945	-2.265	-2.703	-2.152	-3.166
1 - 3	1.044	8.720	7.139	-2.589	-4.242	-3.804	-4.266	-4.350	-3.931	-4.592	-4.850	-3.571	-3.814
2 - 3	6.208	4.743	4.811	-.202	-2.064	-3.357	-4.981	-4.959	-2.985	-2.367	-2.147	-1.419	-.648

Table 23 Mean values, standard deviations (in brackets) and t-values for mean value differences data in Normals, Cerebellum partially resected and Unilateral labyrinthine destruction.

SAGITTAL PLANE OPEN-CLOSED EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal N = 43 (1)	-.059 (.146)	.067 (.199)	.031 (.056)	-.330 (.922)	-.230 (.409)	-.233 (.419)	-.227 (.418)	-.218 (.442)	-.276 (.691)	-.226 (.708)	-.198 (.755)	-.230 (1.334)	-.378 (1.499)
Cereb part resect (2) N = 8	-.050 (.076)	.105 (.092)	.065 (.055)	-.126 (.164)	-.279 (.289)	-.345 (.383)	-.444 (.410)	-.458 (.360)	-.351 (.377)	-.194 (.405)	-.126 (.393)	-.185 (.402)	-.264 (.531)
Unilat lab destruct (3) N = 7	-.079 (.096)	.127 (.121)	.097 (.080)	.097 (.273)	-.223 (.271)	-.284 (.334)	-.260 (.318)	-.267 (.285)	-.214 (.168)	-.113 (.156)	-.089 (.191)	-.271 (.323)	-.296 (.642)
1	-2.619	2.182	3.588	-2.320	-3.645	-3.603	-3.510	-3.196	-2.588	-2.069	-1.370	-1.161	-1.635
2	-1.331	3.420	7.522	-.886	-4.421	-5.336	-6.884	-6.716	-3.292	-1.776	-1.081	-.898	-1.141
3	-3.506	4.136	11.225	-.682	-3.533	-4.393	-4.031	-3.915	-2.007	-1.034	-.764	1.316	-1.280

Table 24

Mean value, standard deviations (in brackets) and t-values for mean differences between standing with the eyes open and closed in Normals, Cerebellum partially resected and Unilateral labyrinthic destruction.

Test category	Clinical state ↗	Unilat. lab destruct	Df.
Frontal plane open-cl. eyes	Normal	4.10 (3.35)	3/58 (1/60)
Var. in eq.	Stand.dev. 0.25Hz	0.75Hz (Stand.dev.)	
Sagittal plane open eyes	Normal	10.61 (0.22)	2/64 (1/65)
Var. in eq.	Stand.dev. 0.00Hz	(Stand.dev.)	

Table 25 F-matrix of mean value differences from a linear discriminant analysis. Groups studied: Normal, Unilateral labyrinthine destruction. Results based upon the standard deviation of the time series are in brackets.

Test category	Original classification	Re-classified as	
	Clinical state	Normal	Unilat. lab. destruct.
Frontal plane open-cl eyes	Normal	50 (36)	5 (19)
—''—	Unilat. lab. destruct.	4 (2)	3 (5)
Sagittal plane open eyes	Normal	52 (33)	8 (27)
—''—	Unilat. lab. destruct.	3 (3)	4 (4)

Table 26 Re-classification from a linear discriminant analysis. Groups studied: Normal, Unilateral labyrinthine destruction. Results based upon the standard deviation of the time series are in brackets.

Test category	Clinical state ↗	Cerebellum part. resect.	Unilat. lab. destruct.	Df.
Frontal plane open-cl. eyes	Normal	0.23 (0.49)	4.42 (3.21)	3/65 (1/67)
—''—	Cerebellum part. resect.	—	2.81 (0.77)	—
Var. in eq.	Stand. dev.	0.25Hz 0.75Hz	(Stand. dev.)	
Sagittal plane open eyes	Normal	10.46 (6.83)	7.10 (0.24)	3/70 (1/72)
—''—	Cerebellum part. resect.	—	1.74 (5.19)	—
Var. in eq.	Stand. dev.	0.00Hz 2.25Hz	(Stand. dev.)	
Sagittal plane open-cl. eyes	Normal	0.95 (0.02)	4.09 (0.14)	3/53 (1/55)
—''—	Cerebellum part. resect.	—	0.81 (0.17)	—
Var. in eq.	Stand. dev.	0.25Hz 0.75Hz	(Stand. dev.)	

Table 27 F-matrix of mean value differences from a linear discriminant analysis. Groups studied: Normal, Cerebellum part. resect., Unilateral labyrinth-hic destruction. Results based upon the standard deviation of the time series are in brackets.

Test category	Original classification	Re-classified as		
	Clinical state	Normal	Cerebellum part. resect.	Unilat. lab. destruct.
Frontal plane open-cl. eyes	Normal	27 (28)	23 (10)	5 (17)
—''—	Cerebellum part. resect.	4 (4)	3 (1)	1 (3)
—''—	Unilat. lab. destruct.	1 (2)	3 (1)	3 (4)
Sagittal plane open eyes	Normal	50 (12)	3 (21)	7 (27)
—''—	Cerebellum part. resect.	1 (1)	7 (7)	0 (0)
—''—	Unilat. lab. destruct.	2 (0)	2 (3)	3 (4)
Sagittal plane open-cl. eyes	Normal	33 (1)	7 (22)	3 (20)
—''—	Cerebellum part. resect.	3 (1)	2 (5)	3 (2)
—''—	Unilat. lab. destruct.	3 (2)	1 (1)	3 (4)

Table 28 Re-classification from a linear discriminant analysis. Groups studied: Normal, Cerebellum part. resect., Unilateral labyrinth-hic destruction. Results based upon the standard deviation of the time series are in brackets.

FRONTAL PLANE OPEN EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal N = 89 (1)	-.106 (.179)	-.468 (.102)	-.382 (.068)	-1.036 (.255)	-1.405 (.382)	-1.743 (.634)	-2.026 (.613)	-2.356 (.597)	-2.550 (.566)	-2.568 (.409)	-2.731 (.588)	-3.127 (.863)	-2.543 (.824)
Park dis N = 10 (2)	.049 (.183)	-.418 (.114)	-.355 (.061)	-1.719 (1.734)	-2.299 (1.569)	-3.047 (1.916)	-3.349 (1.796)	-3.889 (1.949)	-2.991 (1.332)	-2.754 (1.425)	-2.831 (1.398)	-3.250 (1.245)	-2.504 (1.225)
Spast parap N = 12 (3)	.278 (.236)	-.541 (.080)	-.355 (.032)	-1.027 (.221)	-1.657 (.455)	-1.992 (.351)	-2.363 (.622)	-2.573 (.515)	-2.666 (.515)	-2.561 (.462)	-2.676 (.469)	-3.035 (.482)	-2.471 (.615)
1 - 2	-5.743	-3.252	-2.634	17.766	15.524	13.643	14.316	17.033	5.169	3.146	1.128	.948	-.314
1 - 3	-14.230	4.747	-2.634	-.234	4.376	2.605	3.646	2.411	1.359	-.113	-.620	-.707	-.580
2 - 3	-8.486	7.999	.000	-18.001	-11.148	-11.037	-10.670	-14.622	-3.808	-3.112	-1.748	-1.653	-.265

Table 29

Mean values, standard deviations (in brackets) and t-values for mean value differences data in Normals, Parkinson's disease and Spastic paraparesis.

FRONTAL PLANE OPEN-CLOSED EYES

Clin state	Stand														2.75—	
	dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	5.00			
Normal N = 55 (1)	-.110 (.153)	.021 (.119)	.002 (.063)	-.025 (.238)	.000 (.310)	.032 (.400)	.042 (.657)	.006 (.652)	-.009 (.354)	.043 (.382)	.020 (.610)	.025 (.884)	.129 (.968)			
Park dis N = 8 (2)	-.210 (.241)	-.041 (.166)	-.015 (.090)	.653 (2.103)	.477 (2.065)	.006 (2.601)	-.099 (2.571)	-.103 (2.416)	.448 (1.843)	.605 (1.726)	.599 (1.664)	.451 (1.646)	.326 (1.472)			
Spast parap N = 10 (3)	-.027 (.181)	.076 (.151)	.037 (.086)	-.184 (.347)	-.300 (.445)	-.300 (.490)	-.381 (.505)	-.389 (.593)	-.221 (.487)	-.057 (.454)	-.021 (.487)	-.121 (.679)	-.104 (.825)			
1	-5.283	1.297	.233	-.772	.000	.586	.470	.067	-.186	.827	.241	.208	.979			
2	-10.086	-2.532	-1.750	20.162	11.308	.110	-1.108	-1.162	9.299	11.639	7.215	3.749	-2.475			
3	1.297	4.693	4.316	-5.682	-7.111	-5.511	-4.262	-4.328	-4.588	-1.097	.253	-1.006	-.790			

Table 30

Mean values, standard deviations (in brackets) and t-values for mean differences between standing with the eyes open and closed in Normals, Parkinson's disease and Spastic paraparesis.

SIGITTAL PLANE OPEN EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75—
Normal N = 60 (1)	.161 (.182)	-.401 (.071)	-.345 (.035)	-1.330 (.751)	-1.696 (.379)	-1.909 (.377)	-2.143 (.410)	-2.411 (.437)	-2.699 (.655)	-2.818 (.654)	-3.000 (.673)	-3.373 (.911)	-3.001 (1.115)
Park dis N = 10 (2)	.150 (.128)	-.415 (.130)	-.373 (.086)	-1.827 (1.690)	-1.823 (.355)	-2.162 (.406)	-2.484 (.452)	-2.924 (1.328)	-2.664 (.406)	-2.572 (.334)	-2.626 (.322)	-2.799 (.329)	-1.969 (.477)
Spast parap N = 11 (3)	.352 (.272)	-.481 (.168)	-.390 (.123)	-1.585 (1.741)	-1.937 (1.653)	-1.956 (.844)	-2.610 (1.561)	-2.840 (1.429)	-2.942 (1.356)	-3.020 (1.355)	-3.129 (1.321)	-3.365 (1.268)	-2.731 (1.169)
1 - 2	.328	1.071	4.344	3.594	1.820	3.644	4.517	6.375	-.290	-2.043	-3.018	-3.422	-5.027
1 - 3	-6.028	5.048	2.638	-1.749	1.633	-2.967	1.669	5.331	2.014	1.667	1.040	-.048	-1.227
2 - 3	-6.028	5.048	2.638	-1.749	1.633	-2.967	1.669	-1.043	2.305	3.720	4.059	3.274	3.722

Table 31 Mean values, standard deviations (in brackets) and t-values for mean value differences of time series, data in Normals, Parkinson's disease and Spastic paraparesis.

SAGITTAL PLANE OPEN-CLOSED EYES

Clin state	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal N = 43 (1)	-.059 (.146)	.067 (.199)	.031 (.056)	-.330 (.922)	-.230 (.409)	-.233 (.419)	-.227 (.418)	-.218 (.442)	-.276 (.691)	-.226 (.708)	-.198 (.755)	-.230 (1.334)	-.378 (1.499)
Park dis N = 8 (2)	-.164 (.183)	-.034 (.151)	-.030 (.089)	.554 (1.931)	.036 (.601)	.248 (.798)	.631 (1.742)	.685 (1.720)	.620 (1.636)	.293 (.679)	.233 (.499)	.260 (.756)	.385 (.956)
Spast parap N = 8 (3)	.032 (.094)	.113 (.181)	.043 (.098)	-.849 (1.765)	-.354 (.250)	-.260 (.416)	.186 (1.425)	-.191 (1.942)	-.098 (.377)	-.104 (.337)	-.116 (.381)	-.170 (.345)	-.205 (.510)
1	-2.619	2.182	3.588	-2.320	-3.645	-3.603	-3.519	-3.196	-2.588	-2.069	-1.670	-1.161	-1.635
2	7.280	1.107	3.472	3.894	.570	3.834	9.783	10.043	5.815	2.682	2.000	1.263	1.664
3	-1.420	3.680	4.976	-5.967	-5.610	-4.021	2.884	-2.801	-.919	-.952	-.995	-.826	-.887

Table 32

Mean values, standard deviations (in brackets) and t-values for mean differences between standing with the eyes open and closed in Normals, Parkinson's disease and Spastic paraparesis.

Test category	Clinical state ↗	Parkinson's disease				Df.
Frontal plane open eyes	Normal		16.35			5/93
			(6.72½)			(1/97)
Var. in eq.	Stand.dev.	0.75Hz	1.50Hz	1.75Hz	2.75Hz	(Stand.dev.)
Frontal plane open-cl. eyes	Normal		7.06			3/59
			(2.51)			(1/61)
Var. in eq.	Stand.dev.	0.50Hz	1.00Hz	(Stand.dev.)		
Sagittal plane open eyes	Normal		11.09			5/64
			(0.03)			(1/68)
Var. in eq.	Stand.dev.	0.00Hz	0.25Hz	1.25Hz	2.75Hz	(Stand.dev.)
Sagittal plane open-cl. eyes	Normal		4.76			2/48
			(3.23)			(1/49)
Var. in eq.	Stand.dev.	1.50Hz	(Stand.dev.)			

Table 33 F-matrix of mean value differences from a linear discriminant analysis. Groups studied: Normal, Parkinson's disease. Results based upon the standard deviation of the time series are in brackets.

Test category	Original classification	Re-classified as	
	Clinical state	Normal	Parkinson
Frontal plane open eyes	Normal	86 (62)	3 (27)
—''—	Parkinson	3 (3)	7 (7)
Frontal plane open-cl. eyes	Normal	51 (33)	4 (22)
—''—	Parkinson	4 (4)	4 (4)
Sagittal plane open eyes	Normal	58 (33)	2 (27)
—''—	Parkinson	2 (7)	8 (3)
Sagitt. plane Open-cl. eyes	Normal	34 (26)	9 (17)
—''—	Parkinson	4 (3)	4 (5)

Table 34 Re-classification from a linear discriminant analysis. Groups studied: Normal, Parkinson's disease. Results based upon the standard deviation of the time series are in brackets.

Test category	Clinical state ↗	Parkinson's disease			Spastic parapares	Df.
Fronal plane open eyes	Normal	15.03 (6.26)			13.36 (45.24)	5/104 (1/108)
—''—	Parkinson's disease	—			6.81 (8.31)	—
Var. in eq.	St. dev.	0.75Hz	1.50Hz	2.00Hz	2.75Hz	(St. dev.)
Frontal plane open-cl. eyes	Normal	7.64 (2.47)			0.66 (1.55)	3/68 (1.70)
—''—	Parkinson's disease	—			4.17 (4.47)	—
Var. in eq.	St. dev.	0.50Hz	1.00Hz	(St. dev.)		
Sagittal plane open eyes	Normal	4.42 (0.10)			14.07 (20.31)	6/73 (1.78)
—''—	Parkinson's disease	—			8.22 (10.38)	—
Var. in eq.	St. dev.	0.00Hz	0.25Hz	1.00Hz	1.25Hz	2.25Hz (St. dev.)

Table 35 F-matrix of mean value differences from a linear discriminant analysis. Groups studied: Normal, Parkinson's disease, Spastic parapares. Results based upon the standard deviation of the time series are in brackets.

Test category	Original classification	Re-classified as		
	Clinical state	Normal	Parkinson's disease	Spastic parap.
Frontal plane open eyes	Normal	78 (62)	4 (21)	7 (6)
—''—	Parkinson's disease	2 (3)	6 (5)	2 (2)
—''—	Spastic parap.	3 (2)	0 (1)	9 (9)
Frontal plane open-cl. eyes	Normal	33 (12)	4 (22)	18 (21)
—''—	Parkinson's disease	3 (1)	4 (4)	1 (3)
—''—	Spastic parap.	3 (2)	0 (2)	7 (6)
Sagittal plane open eyes	Normal	55 (12)	5 (27)	0 (21)
—''—	Parkinson's disease	3 (6)	6 (3)	1 (1)
—''—	Spastic parap.	1 (1)	0 (1)	10 (9)

Table 36 Re-classification from a linear discriminant analysis. Groups studied: Normal, Parkinson's disease, Spastic parapares. Results based upon the standard deviation of the time series are in brackets.

FRONTAL PLANE OPEN EYES

	MEAN		LINEAR TREND		STANDARD DEVIATION	
	degree angle	cm, distance	degree angle	cm, distance	degree angle	cm, distance
Astasia abasia	.800	2.330	.316	.920	.358	1.043
Spinal ataxia	.510	1.486	.343	.999	.474	1.501
Cerebral ataxia	.593	1.748	.233	.691	.407	1.298
Unilat lab.destr.	.159	.457	.130	.373	.163	.468
Cerebellum part resect.	.610	1.732	.138	.392	.172	.488
Parkinson's disease	.933	2.665	.319	.911	.160	.457
Spastic paraparesis	.510	1.465	.263	.756	.271	.779

Table 37 Sample means of the mean, linear trend and standard deviation of the time series, transformed into angular values for the position vector of the mass centre and the position of the head in cm distance. (Eq 3 and 4)

FRONTAL PLANE CLOSED EYES

	MEAN		LINEAR TREND		STANDARD DEVIATION	
	degree angle	cm, distance	degree angle	cm, distance	degree angle	cm, distance
Astasia abasia	.976	2.803	.287	.825	.385	1.106
Spinal ataxia	.281	.799	.283	.803	.499	1.417
Cerebral ataxia	.551	1.584	.301	.866	.441	1.267
Unilat lab. destr.	.326	.930	.130	.371	.166	.475
Cerebral part resect.	.593	1.703	.135	.389	.202	.580
Parkinson's disease	.670	1.902	.128	.364	.226	.640
Spastic paraparesis	.389	1.110	.234	.669	.324	.924

Table 38

Sample means of the mean, linear trend and standard deviation of the time series, transformed into angular values for the position vector of the mass centre and the position of the head in cm distance. (Eq 3 and 4)

SAGITTAL PLANE OPEN EYES

	MEAN		LINEAR TREND		STANDARD DEVIATION	
	degree angle	cm, distance	degree angle	cm, distance	degree angle	cm, distance
Astasia abasia	.926	2.628	.241	.684	.499	1.417
Spinal ataxia	1.316	3.735	.279	.791	.406	1.153
Cerebral ataxia	.999	2.869	.291	.837	.434	1.247
Unilat lab. destr.	.963	2.750	.167	.477	.191	.545
Cerebral part resect.	1.033	2.967	.231	.665	.308	.886
Parkinson's disease	1.183	3.358	.169	.479	.202	.573
Spastic paraparesis	1.284	2.158	.437	1.248	.321	.918

Table 39

Sample means of the mean, linear trend and standard deviation of the time series, transformed into angular values for the vector of the mass centre and the position of the head in cm distance. (Eq 3 and 4)

SAGITAL PLANE CLOSED EYES

	MEAN		LINEAR TREND		STANDARD DEVIATION	
	degree angle	cm, distance	degree angle	cm, distance	degree angle	cm, distance
Astasia abasia	.734	2.084	.719	2.040	.515	1.462
Spinal ataxia	.997	2.831	.414	1.176	.426	1.209
Cerebral ataxia	1.257	3.612	.386	1.108	.690	1.959
Unilat lab.destr.	.876	2.501	.094	.269	.229	.654
Cerebral part resect.	.900	2.586	.227	.653	.346	.993
Parkinson's disease	1.243	3.528	.191	.543	.307	.872
Spastic paraparesis	1.387	3.962	.236	.673	.335	.957

Table 40

Sample means of the mean, linear trend and standard deviation of the time series, transformed into angular values for the position vector of the mass centre and the position of the head in cm distance. (Eq 3 and 4)

IV

EFFECTS OF L-DOPA UPON QUASISTATIONARY STANDING IN PARKINSON'S DISEASE

By

P.G. JEPPSSON and HALDO ÖSTLUND

INTRODUCTION

The most reliable effect of treatment with 1-Dopa in Parkinson's disease is reduction of hypochinesia and rigidity (9), which in quasistationary standing might manifest itself by increased magnitude and/or increased velocity of the postural movements. Reduced tremor and improvement of the righting reflexes could add to the final result.

Differences between "static" standing before and during treatment with 1-Dopa in Parkinson's disease are in this study compared to differences between a primary test and a replication in healthy subjects.

METHODS

Patients suffering from Parkinson's disease were examined neurologically and according to the method for measurement of postural movements in "static" standing as described in I. In a first group, consisting of eight patients, d,1-Dopa and placebo were given one week each, using a double blind cross over administration procedure. By chance half the number of patients were treated during the first week with placebo and during the second week with d,1-Dopa and in the other half of the patient group the order was the reverse. This patient group is identical with the group described in III but for two patients, who had to be excluded for technical reasons. The dosage of d,1-Dopa was 3 grammes in six patients, in one patient 6 grammes and in one patient 9 grammes. "Static" standing was examined at the end of each treatment period together with estimation of the clinical state with regard to rigidity, tremor and the time needed by the patients to take off and put on their shoes. An overall judgement of the clinical state was also made. The difference vectors between time series characters obtained during the treatment with placebo and d,1-Dopa respectively were estimated. The results were compared to the test replication differences obtained in the healthy sample, I. The group means were examined statistically by a linear discriminant analysis as described in III.

In a second patient group, consisting of eleven patients, examination of the clinical state and the pattern of postural movements in the frontal plane, during "static" standing with the eyes open, were performed before treatment and during treatment with an optimal dosage of 1-Dopa, as judged clinically. The median and range of the dosage of 1-Dopa were 4.5 and 1.5-7.5 grammes. The reference group of healthy subjects used in this study was with regard to the average and range of age (median 51, range 38-66) equal to the patient group. Otherwise the method was similar to that described above.

Rigidity and tremor were rated subjectively and marked off in a scale 0-3. The time needed to take off and put on the shoes was measured in seconds. The data, upon which the discriminant analyses were based, consisted of differences d,1-Dopa — placebo and 1-Dopa — before treatment respectively. Differences of reverse order were used in the discriminatory analyses due to a programming error.

RESULTS AND COMMENTS

Clinical measurements, during treatment with placebo and d,1-Dopa in the first patient group and before and during treatment with 1-Dopa in the second patient group respectively, are shown in (Table 1). The time needed for the patients to take off and put on their shoes was in all cases shorter during treatment with d,1-Dopa and 1-Dopa respectively. Improvements with regard to rigidity and tremor were in the first group found in three patients. In two patients the improvement was simultaneous. In the second patient group two individuals displayed reduced tremor and six patients reduced rigidity. In two patients reductions of tremor and rigidity was simultaneous. In one patient tremor was increased during treatment with 1-Dopa.

The first patient group

Frontal plane, open eyes

The body movements during treatment with placebo are rather small and slow, but for a locally increased frequency content above 1.75 Hz, reasonably due to tremor (compare III). In the interval 0.5-1.5 Hz the frequency content is very small. During treatment with d,1-Dopa, irregularities of the frequency spectrum are levelled. The smoothing of the discrepancies in the spectral content between very slow modes and frequencies in the interval 0.5-1.75 Hz can be interpreted to correspond to reduction of rigidity. (Table 2).

The result of the discriminant analysis in Tables 3 and 4 shows differences between the patient group and the normal sample.

Frontal plane, closed eyes

The postural movements are larger than during standing with the eyes open. During treatment with d,1-Dopa the content of very slow modes is somewhat increased, maybe indicating improved postural control (Table 2).

The results from the discriminant analysis indicate significant differences between the normal group and the patient group. (Tables 3 and 4).

Sagittal plane, open eyes

During treatment with placebo the postural movements are relatively small in range and of low velocity. During treatment with d,1-Dopa the movements are of increased range. Contrary to the case concerning movements in the frontal plane there is an increased content of slow modes. Need of improved postural control, due to enhanced magnitude of the movements, is a possible explanation. (Table 2).

A discriminant analysis, (Tables 3 and 4) shows significant differences between the group of healthy subjects and the first patient group.

Sagittal plane, closed eyes

During treatment with placebo the movements are of comparatively wide range and of about the same velocity as in the previous case. During treatment with d, 1-Dopa the range of the postural movements is reduced and, simultaneously, they are somewhat increased in velocity, see (Table 2). Reduced rigidity might be the cause.

A discriminant analysis, (Tables 3 and 4), indicates significant differences between the Normal group and the group of patients suffering from Parkinson's disease.

The second patient group

The postural movements in the frontal plane during "static" standing with the eyes open are of larger magnitude than in Normals. The total variance is to a great extent due to slow modes before treatment with 1-Dopa. During treatment with 1-Dopa the magnitude of the postural movements is slightly reduced and of increased velocity. The results thus resemble those obtained in the first patient group regarding the corresponding test category. (Table 5).

Significant differences between the Normal group and the group of patients suffering from Parkinson's disease were revealed by a linear discriminant analysis. (Table 6).

It is concluded that the study has revealed significant changes of the body movements in "static" standing, attributable to treatment with 1-Dopa, mainly manifested by lessened rigidity and improved postural control.

DISCUSSION

Changes of the postural movements in "static" standing during treatment with 1-Dopa in Parkinsonism are found in this study. The results are in some cases widely dispersed, which to a substantial degree might be due to the presence of different extents of tremor and rigidity. The results are nevertheless supposed to gain a sufficient reliability from the fact that they seem to be interpretable in clinical terms as changes such as reduced rigidity and improved stability control. Some of the apparent inconsistencies are eliminated or at least reduced by considering the sample averages before treatment as a reference estimate of the behavioural pattern. Reduction of the sample standard deviations might have been attainable by theoretical adjustment of the spectral densities based upon elimination of the supposed influences of tremor.

Tables IV

Standard deviations are placed in brackets below corresponding mean values. In the F-matrices and the reclassifications the results obtained at the first step are placed in brackets.

Patient Nr	Time for shoeing		Tremor		Rigidity	
	Placebo	dl-Dopa	Placebo	dl-Dopa	Placebo	dl-Dopa
FIRST PATIENT GROUP						
1	44	41	0	0	2	2
2	442	261	1	1	2	2
3	212	147	3	3	2	2
4	475	330	2	2	2	2
5	149	88	2	1	2	1
6	670	565	1	0	2	1
7	221	101	1	0	2	2
8	960	655	2	2	3	2

	Untreated	l-Dopa	Untreated	l-Dopa	Untreated	l-Dopa
SECOND PATIENT GROUP						
1	221	140	0	0	2	1
2	735	168	2	2	2	2
3	202	113	2	3	2	1
4	84	44	3	1	2	1
5	86	47	0	0	2	2
6	45	44	2	2	2	2
7	59	39	0	0	2	1
8	27	21	2	2	1	1
9	53	44	1	1	0	0
10	93	75	3	3	3	2
11	126	53	1	0	2	1

Table 1 Results of a clinical examination with regard to the time needed for shoeing in seconds and the degree of tremor and rigidity, subjectively rated (scale 0—3) in the two Parkinsonism groups. During treatment with placebo and d,l-Dopa, before respectively during treatment with l-dopa.

Test	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
FRONTAL PLANE OPEN EYES													
N = 8													
Mean, placebo	.047	-.422	-.353	-1.698	-2.286	-3.057	-3.303	-3.862	-2.851	-2.699	-2.834	-3.157	-2.581
Mean and st. dev, placebo-d, l-Dopa	-.021 (.233)	.041 (.062)	.006 (.041)	-.201 (.185)	-.261 (.375)	-.718 (1.523)	-.724 (1.397)	-.676 (1.242)	-.130 (.388)	-.085 (.496)	-.075 (.491)	-.066 (.413)	-.074 (.604)
FRONTAL PLANE CLOSED EYES													
N = 7													
Mean, placebo	.257	-.380	-.340	-2.198	-2.756	-3.063	-3.204	-2.759	-3.294	-3.304	-3.833	-3.506	-3.605
Mean and st. dev, placebo-d, l-Dopa	.006 (.168)	-.077 (.094)	-.046 (.070)	.851 (2.157)	.889 (2.009)	.806 (1.895)	.817 (1.788)	.817 (1.775)	.814 (1.630)	.817 (1.527)	.837 (1.487)	.793 (1.443)	.880 (1.468)
SAGITTAL PLANE OPEN EYES													
N = 8													
Mean, placebo	.161	-.408	-.380	-1.875	-1.815	-2.064	-2.463	-2.915	-2.641	-2.572	-2.633	-2.784	-1.945
Mean and st. dev, placebo-d, l-Dopa	-.128 (.181)	-.058 (.116)	-.056 (.085)	-.009 (2.787)	.633 (1.676)	.568 (1.677)	.529 (1.642)	.166 (2.171)	.473 (1.561)	.479 (1.503)	.566 (1.408)	.823 (1.311)	.699 (.723)
SAGITTAL PLANE CLOSED EYES													
N = 6													
Mean, placebo	.325	-.374	-.350	-2.379	-1.921	-2.312	-3.094	-3.600	-3.261	-2.965	-2.866	-3.046	-2.433
Mean and st. dev, placebo-d, l-Dopa	.085 (.189)	.132 (.222)	.058 (.121)	-.282 (.257)	-.322 (.317)	-.467 (.444)	-1.002 (1.588)	-1.052 (1.456)	-1.113 (1.469)	-.548 (.640)	-.403 (.589)	-.600 (.646)	-.831 (1.041)

Table 2 Time series data during treatment with placebo, mean value, and the difference of series obtained during treatment with placebo and d,l-Dopa, mean value and standard deviation

Test category	Clinical state ↗	Parkinson's disease	Df.
Frontal plane open eyes Var. in eq.	Normal	3.97 (0.81) Stand.dev. 0.00Hz 0.25Hz 1.25Hz 1.75Hz 2.00Hz 2.75—5.00Hz (Stand.dev.)	7/45 (1/51)
Frontal plane closed eyes Var. in eq.	Normal	4.28 (0.28) Stand.dev. 0.25Hz 0.75Hz (Stand.dev.)	4/20 (1/23)
Sagittal plane open eyes Var. in eq.	Normal	6.00 (4.61) Stand.dev. 0.00Hz 0.25Hz 2.75Hz (Stand.dev.)	4/23 (1/26)
Sagittal plane closed eyes Var. in eq.	Normal	6.98 (2.80) Stand.dev. 1.25Hz 2.50Hz (Stand.dev.)	3/13 (1/15)

Table 3 F-matrix of mean value differences from a linear discriminant analysis. Groups studied: Normal, Parkinson's disease. Results based upon the standard deviation of the time series are in brackets.

Test	Original classification	Re-classified as	
	Clinical state	Normal	Parkinson's disease
Frontal plane open eyes —''—	Normal	42 (26)	3 (19)
	Parkinson's disease	3 (2)	5 (6)
Frontal plane closed eyes —''—	Normal	16 (7)	2 (11)
	Parkinson's disease	0 (3)	7 (4)
Sagittal plane open eyes —''—	Normal	19 (15)	1 (5)
	Parkinson's disease	1 (2)	7 (6)
Sagittal plane closed eyes —''—	Normal	11 (7)	0 (4)
	Parkinson's disease	1 (1)	5 (5)

Table 4 Re-classification from a linear discriminant analysis. Groups studied: Normal, Parkinson's disease. Test-category: Frontal plane open eyes. Results based upon the standard deviation of the time series are in brackets.

	Stand dev	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75— 5.00
Normal N = 36													
Mean vector of primary test	.069 (.210)	-.406 (.070)	-.347 (.032)	-1.255 (.378)	-1.794 (.906)	-1.691 (.452)	-2.068 (.365)	-2.343 (.376)	-2.596 (.392)	-2.723 (.303)	-2.851 (.402)	-3.250 (.770)	-2.776 (.820)
Parkinsonism N = 11													
Mean vector before treatment	.159	-.543	-.448	-1.078	-1.528	-1.902	-2.461	-2.601	-2.332	-2.125	-2.249	-2.450	-1.589
Normal N = 36													
Primary test - replication	-.045 (.213)	-.014 (.125)	-.011 (.059)	.173 (1.044)	.011 (.551)	-.130 (.891)	-.152 (.820)	-.112 (.787)	-.058 (.604)	.029 (.556)	-.040 (.841)	-.042 (1.370)	.050 (1.210)
Parkinsonism N = 11													
Diff. vector before - during treatment with l-Dopa	.052 (.188)	.039 (.204)	.025 (.157)	-.464 (1.573)	-.514 (1.520)	-.513 (1.405)	-.525 (1.368)	-.498 (1.409)	-.459 (1.426)	-.469 (1.485)	-.505 (1.478)	-.487 (1.414)	-.449 (1.429)

Table 5

Mean values of result vectors in primary test in Normals and before treatment with l-Dopa in a Parkinsonism group. Differences between a primary test and a replication in healthy subjects and differences between before and during treatment with l-Dopa in Parkinsonism. Test category: Frontal plane open eyes. Sample standard deviation are placed within brackets.

Test	Clinical state	Parkinson's disease	Df.
Frontal plane open eyes	Normal	2.645 (.008)	7/39 (1/45)
N = 11	Parkinson's disease	—	—
Var. in eq.	Stand.dev.	0.50Hz 1.00Hz 1.25Hz 1.75Hz 2.00Hz 2.25Hz 2.50Hz	(Stand.dev.)

Table 6 F-matrix of mean value differences from a linear discriminant analysis. Groups studied: Normal, Parkinson's disease. Results based upon the standard deviation of the time series are in brackets.

Test category	Original classification	Re-classified as	
	Clinical state	Normal	Parkinson's disease
Frontal plane open eyes	Normal	29 (18)	7 (18)
	Parkinson's disease	2 (5)	9 (6)

Table 7. Reclassification from a linear discriminant analysis. Groups studied: Normal, Parkinson's disease

GENERAL DISCUSSION

The aim of this study has been to describe an objective method for assessment of the acuity of balance. The fact that the standing human being never settles into an immobile posture (29, 22) was utilised to obtain a reasonable solution of the problem stated.

The very restricted body movements reported concerning "static" standing, that is when a person tries to stand as immobile as possible, are, due to a low consumption of energy (35) and small and intermittent muscular activity (1, 22), supposed to be dominantly passive in nature. The irregular swings to and fro of the body might indicate that the human body is in lack of inherent stability (32). A dynamic control system would then be necessary in order to secure stability, which reasonably is effectuated by the righting reflexes (16). Persistence of some degree of body movement in "static" standing might have the meaning to preserve physiological integrity of the body. In vital biological systems (vital organisms) some motor activity is constantly seen and a certain preparedness would be indispensable at any time. The necessary dirigibility then presumes some flexibility of the body (3). The conclusion would then be that the biological system defined by the standing human being, trying to stand as still as possible, has roughly speaking two opposite objectives, one being preservation of a certain degree of mobility, which on the other hand must be restricted in range and velocity in the interest of stability.

The present results show that it is not unrealistic in the case of healthy individuals to conceive time series of body movements in "static" standing during a period of two minutes as stationary stochastic processes. Fourier analysis is thus applicable (12, 39). Previous considerations imply that stationarity would prevail only for a restricted period of time. See also (32).

SUMMARY

Variations of the position of the mass centre in "static" standing were indirectly measured. The recorded oscillations defined approximately stationary stochastic processes during a period of two minutes. The time series were identified by measures of the standard deviation and spectral density (in the frequency band 0-5 Hz). The differences between a primary test and a replication were small and insignificantly different from zero. The association between the pattern in quasistationary standing and personality described according to the model of Sjöbring was conceived as manifesting differences in aim. A construct validation of the Sjöbring personality system was attained at the same time.

To a substantial degree large body movements seem to be associated with a great proportion of slow modes, in Normals. This might mean that the individual tends to restrict the energy content of the body movements in the interest of stability.

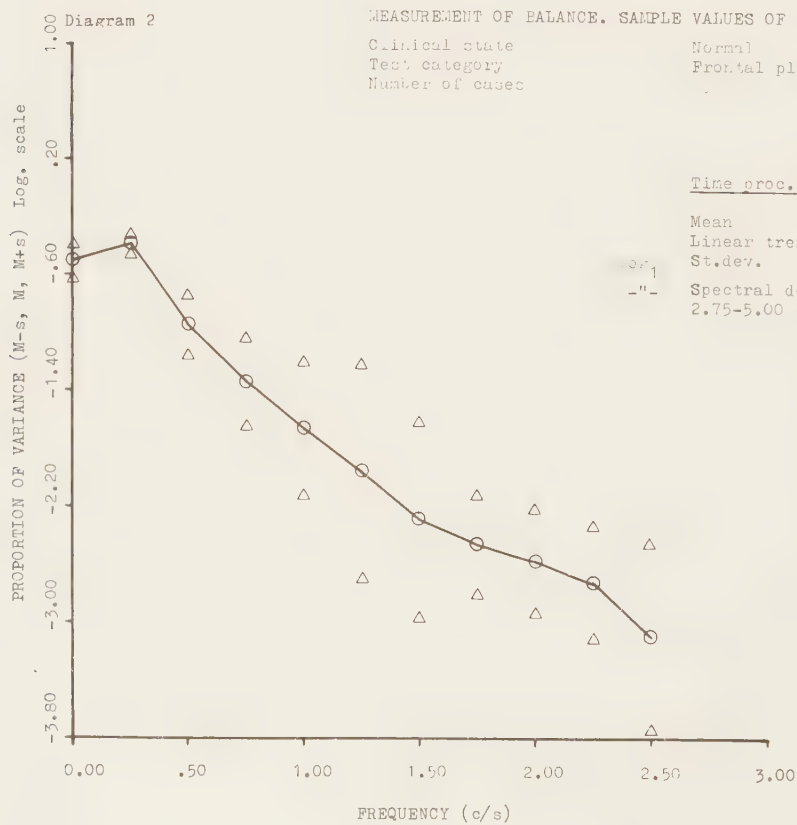
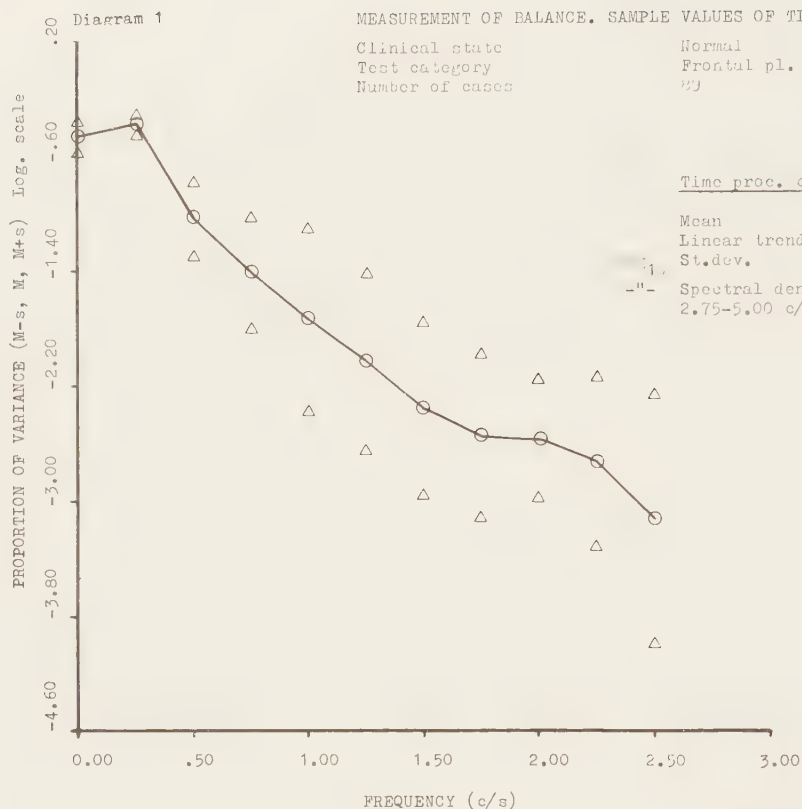
In psychogenic Astasia abasia the very large postural oscillations were to a great degree due to slow modes, in contrast to Spinal and Cerebellar ataxia. Based upon the findings in Normals these results were supposed to indicate differences with regard to somatic resources for stability control. Consistent with general clinical experiences a greater divergence between standing with the eyes open and closed was found in Spinal ataxia than in Cerebellar ataxia. The findings gain support from the correspondence between the time series recorded in Cerebellar ataxia, semiologically defined and a group of patients previously subjected to a partial resection of the Cerebellum.

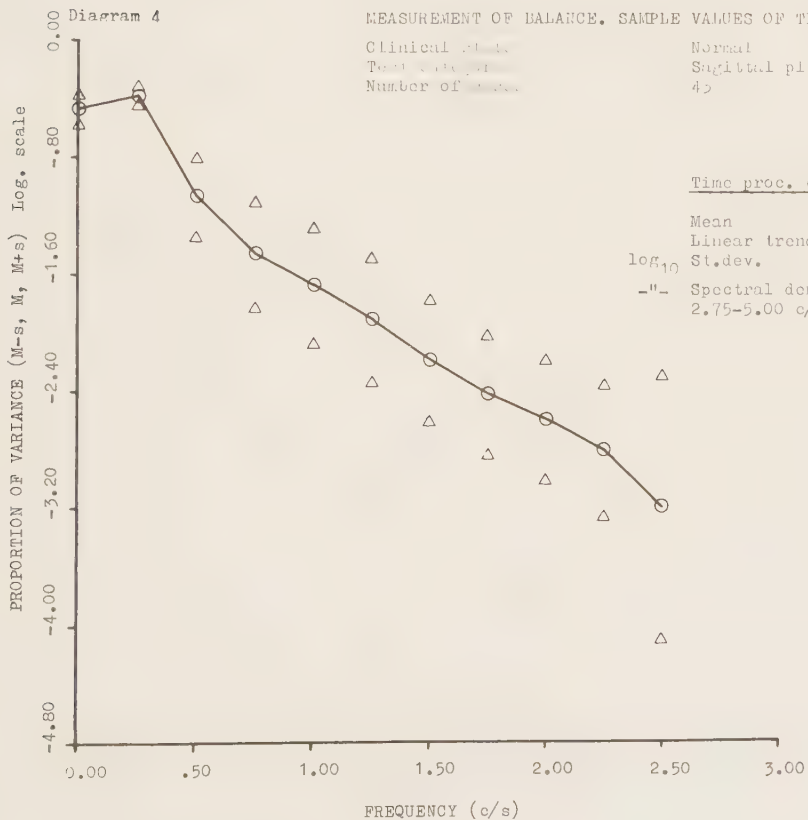
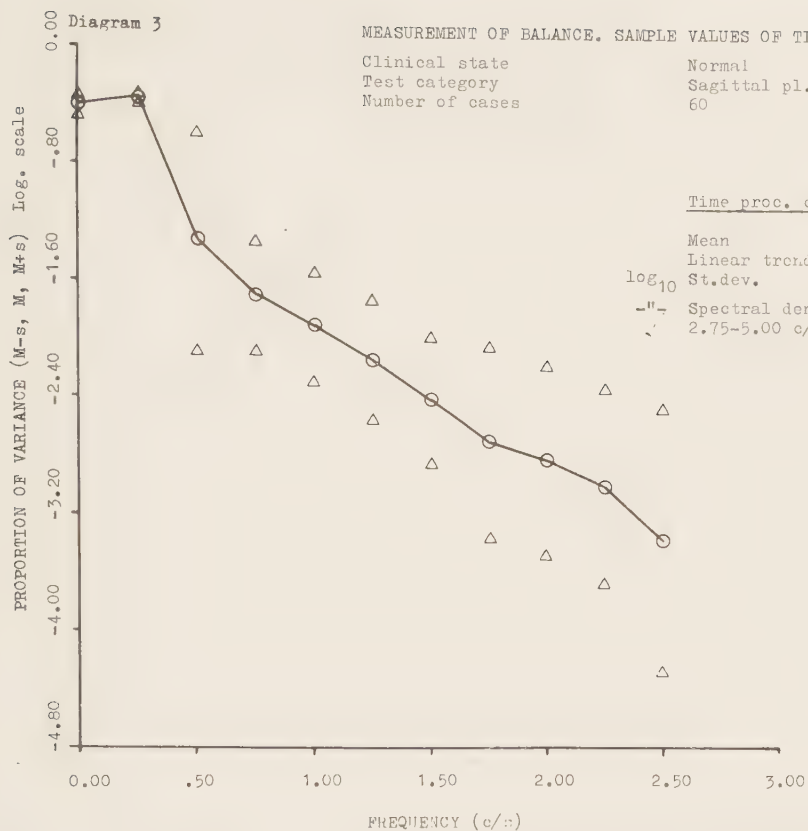
The great dominance of slow modes in Parkinson's disease might reflect damping as a consequence of rigidity. A great proportion of frequencies approximately in the interval 2-5 Hz is reasonably due to tremor. No signs of damping were found in Spastic paraparesis.

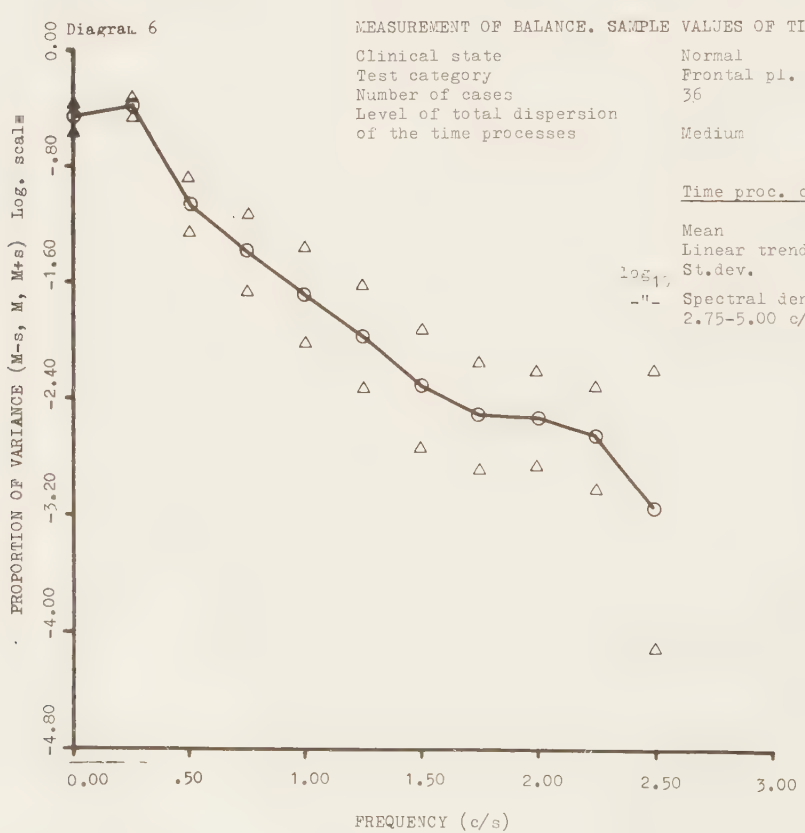
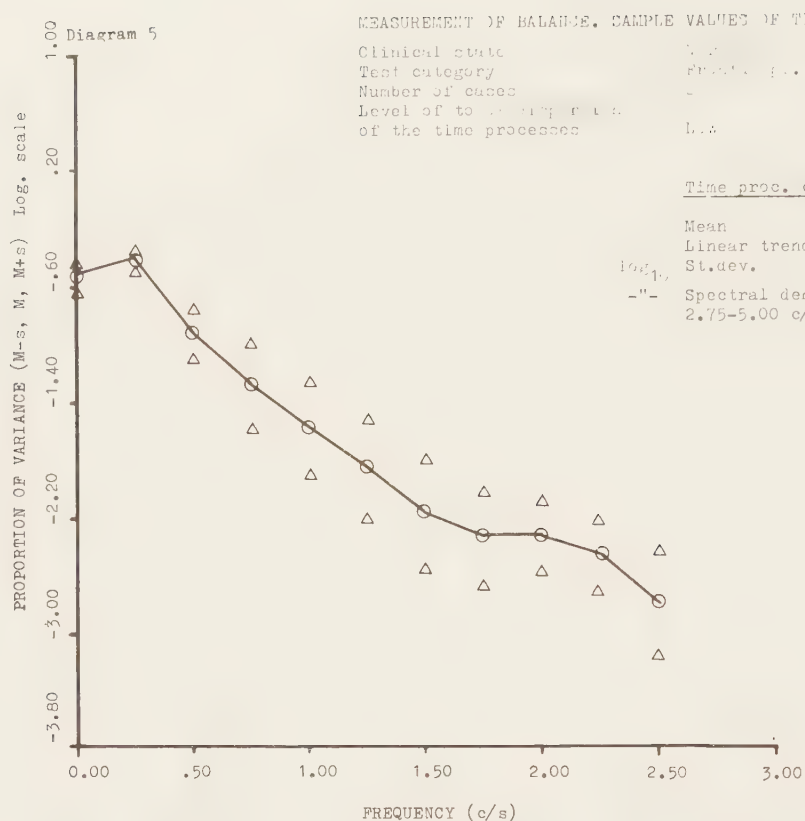
Postural oscillations in both the frontal and sagittal plane differed from Normals in patients previously subjected to Unilateral labyrinthic destruction.

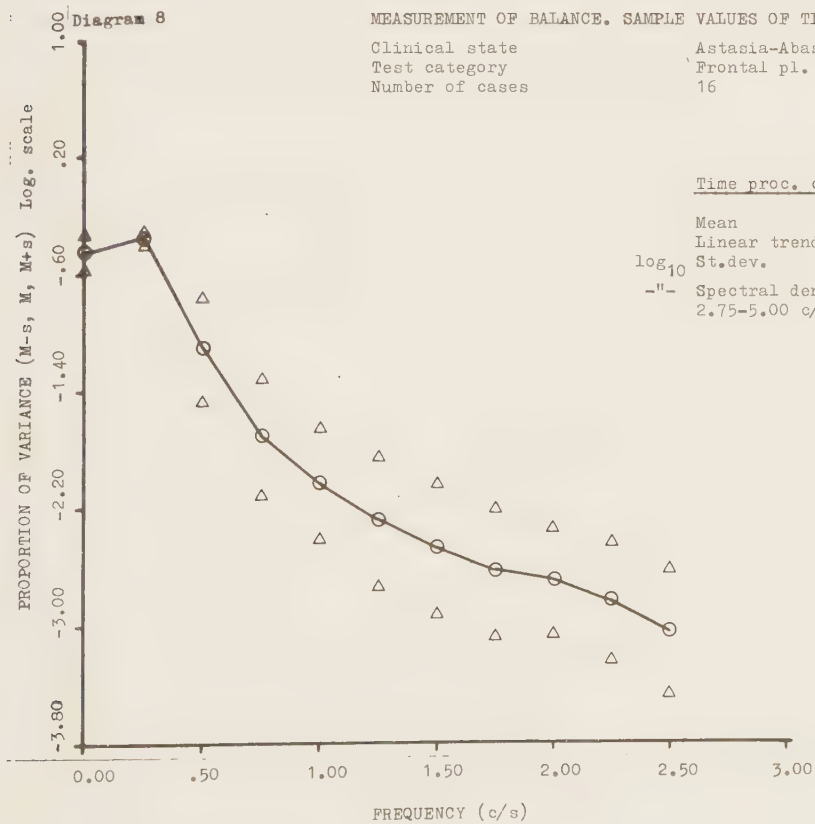
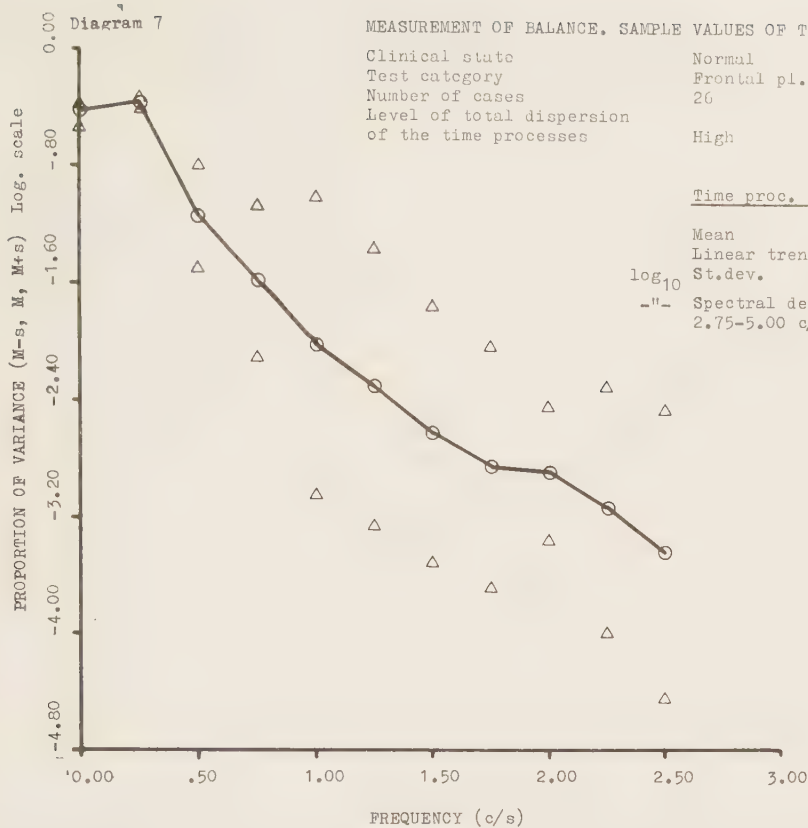
The practical use of studying body movements in "static" standing was exemplified by differences between standing, before and during treatment with L-Dopa in Parkinson's disease.

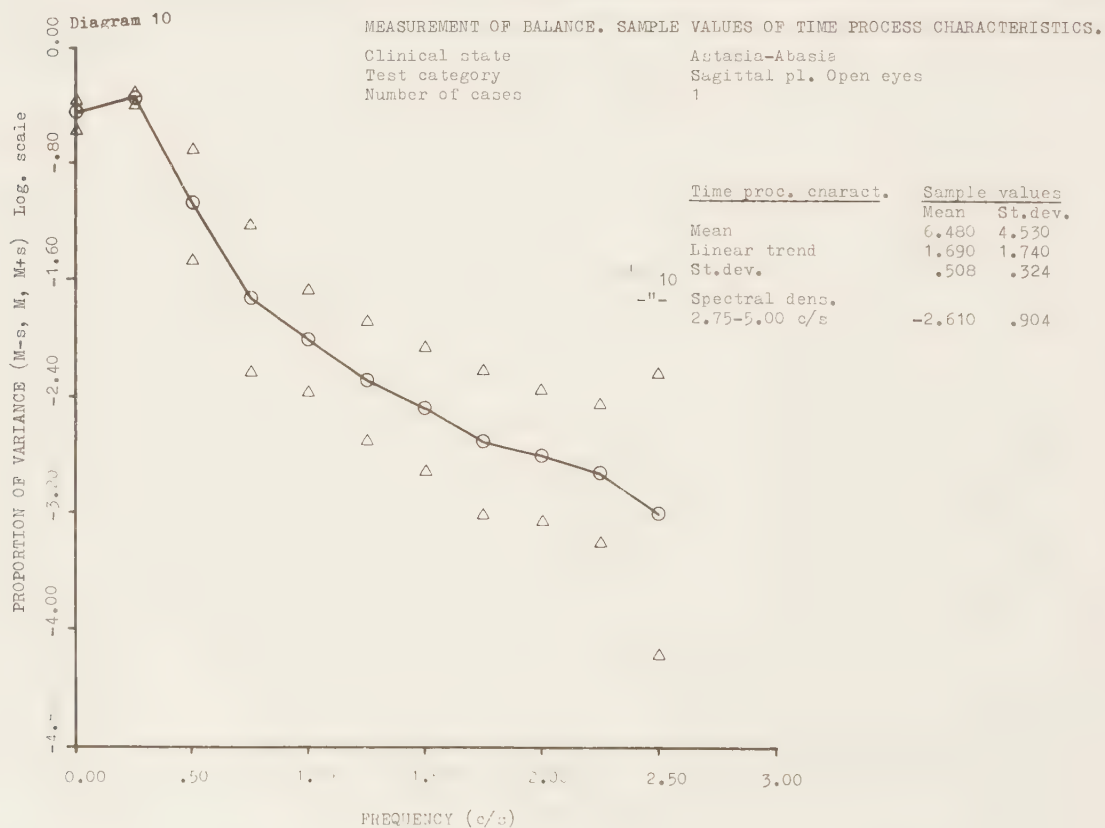
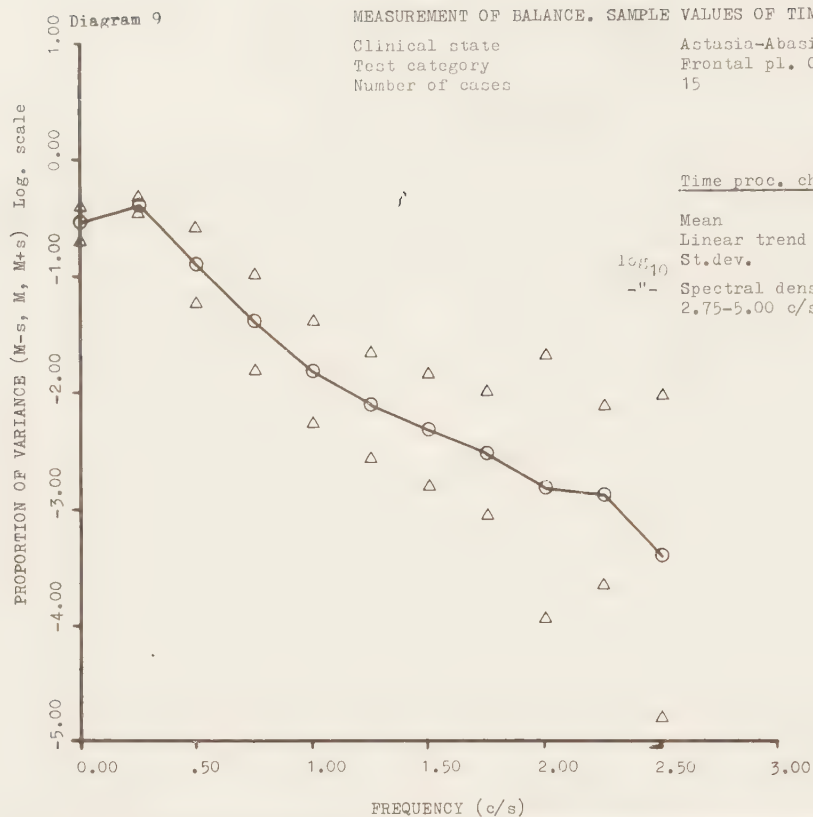
DIAGRAM

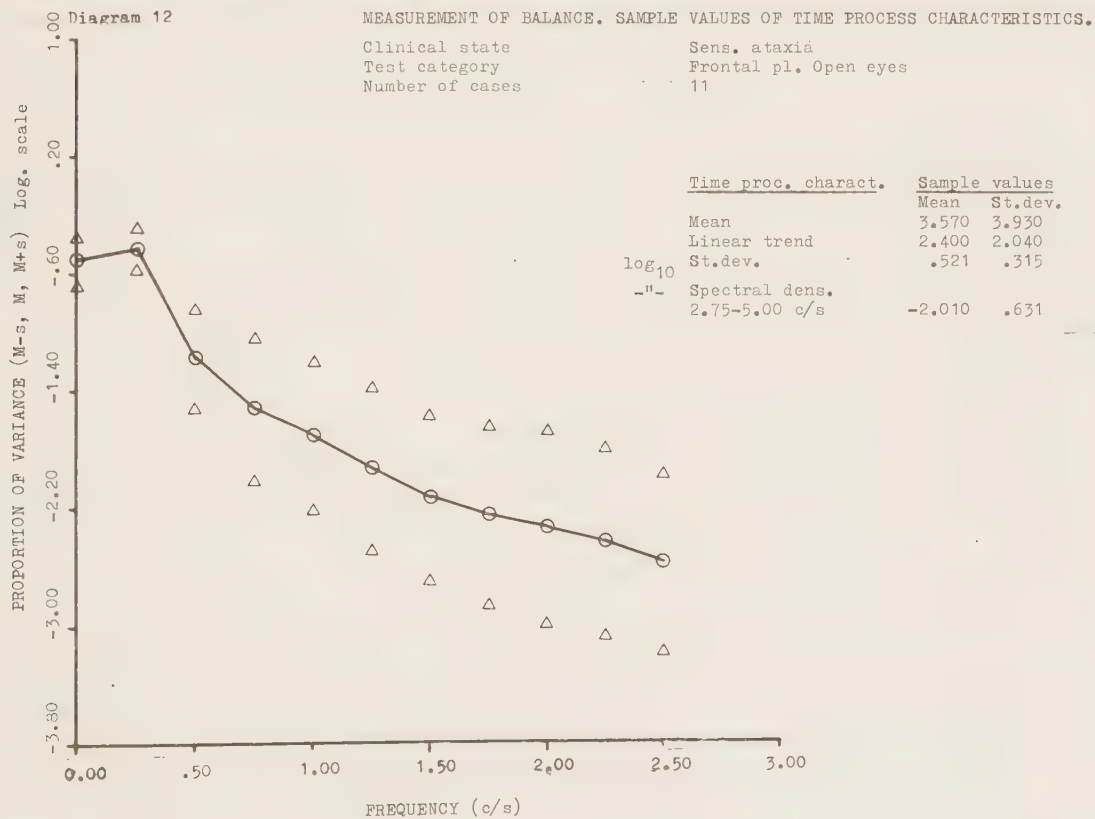
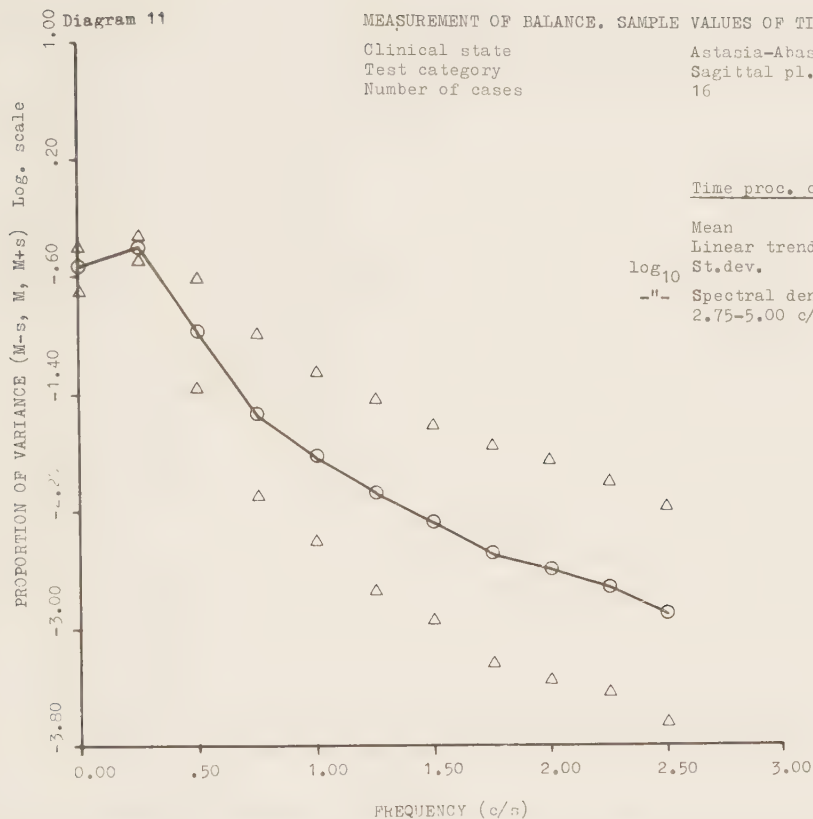


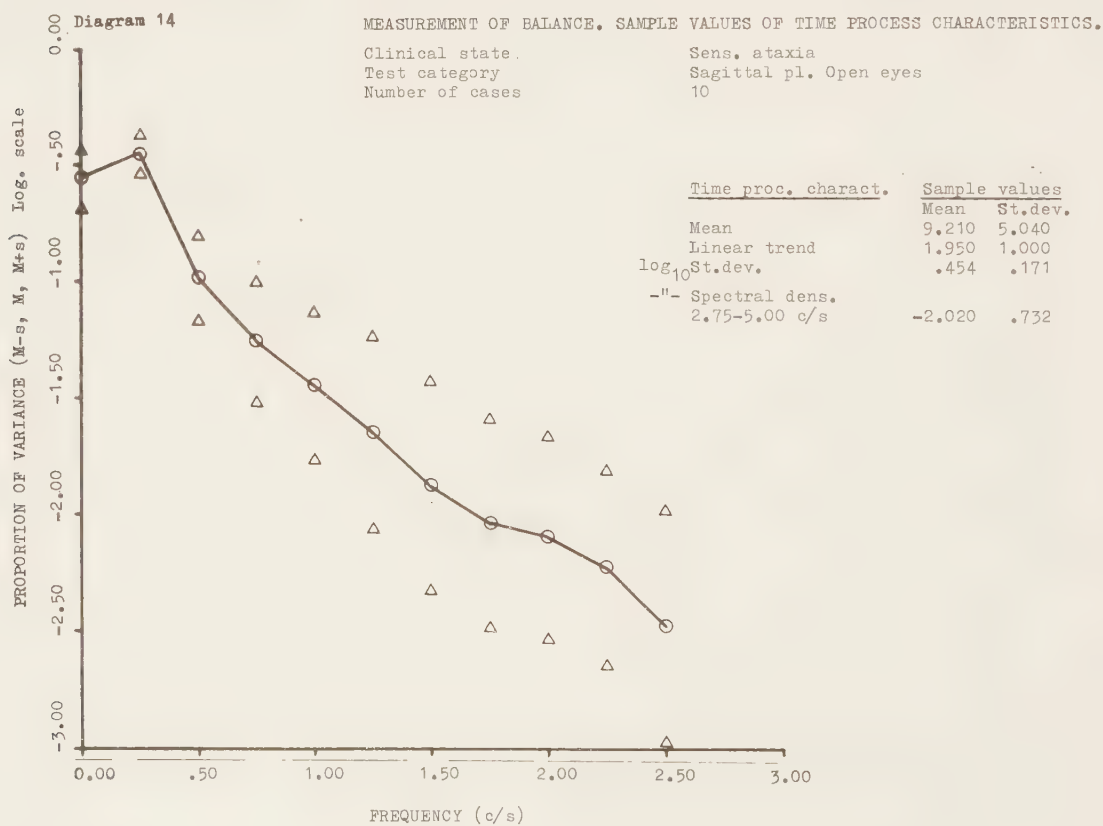
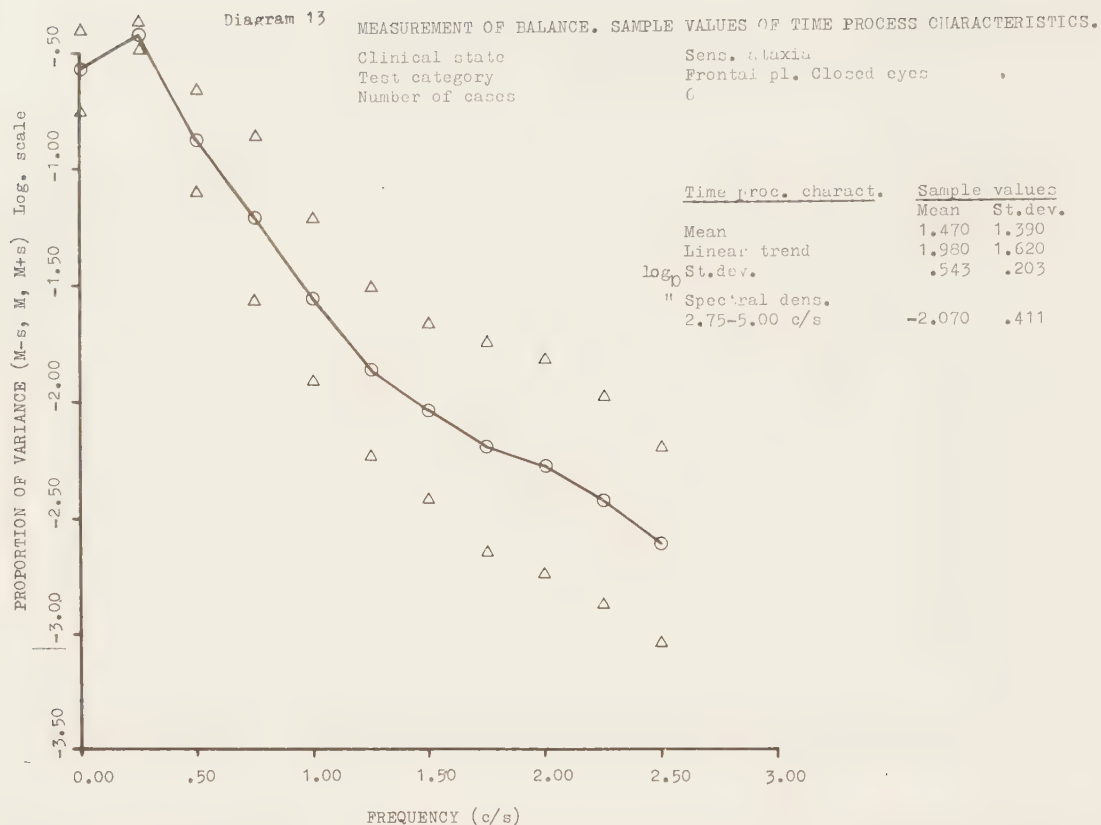


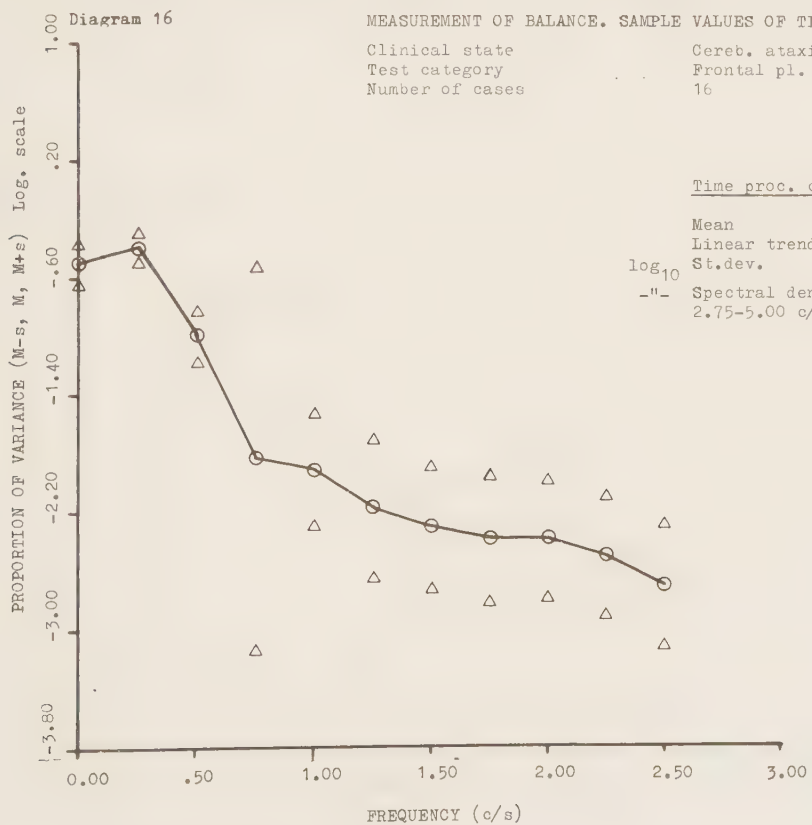
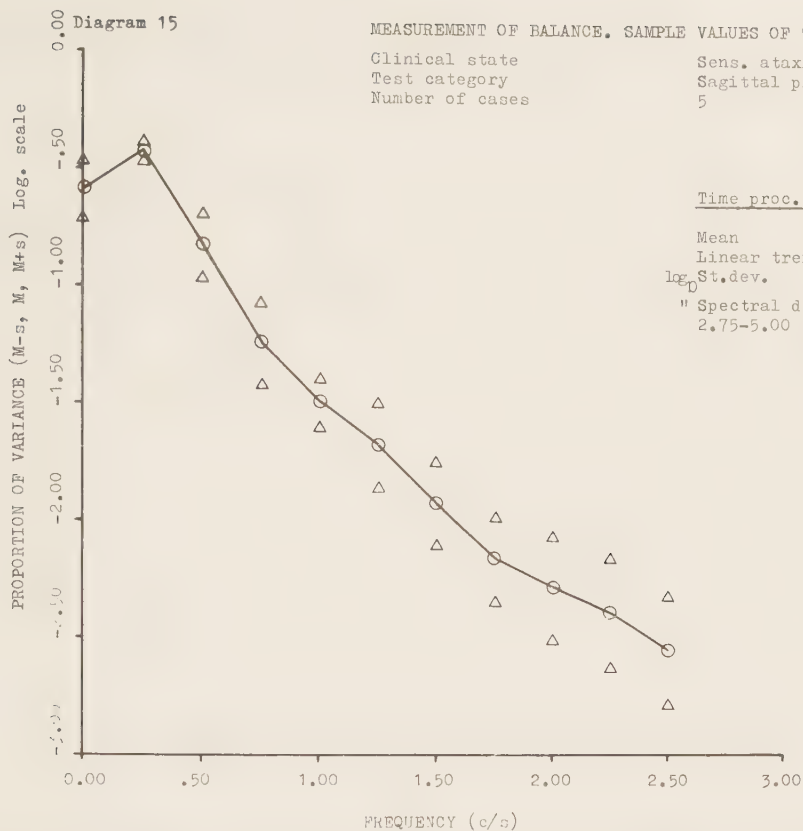


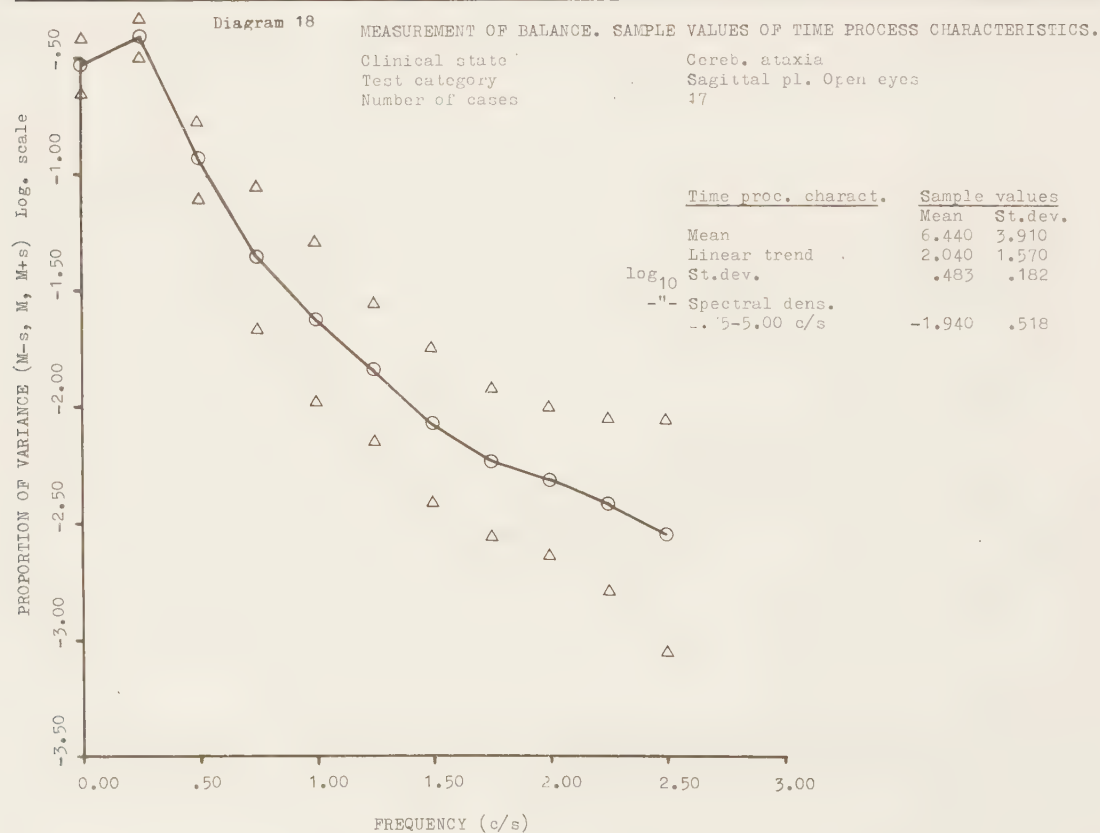
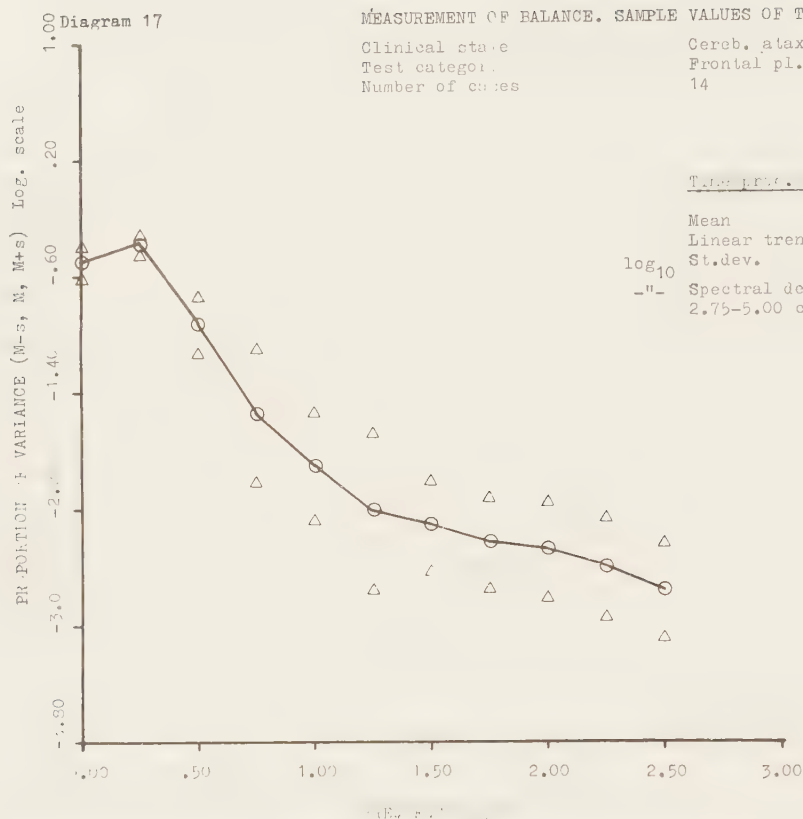


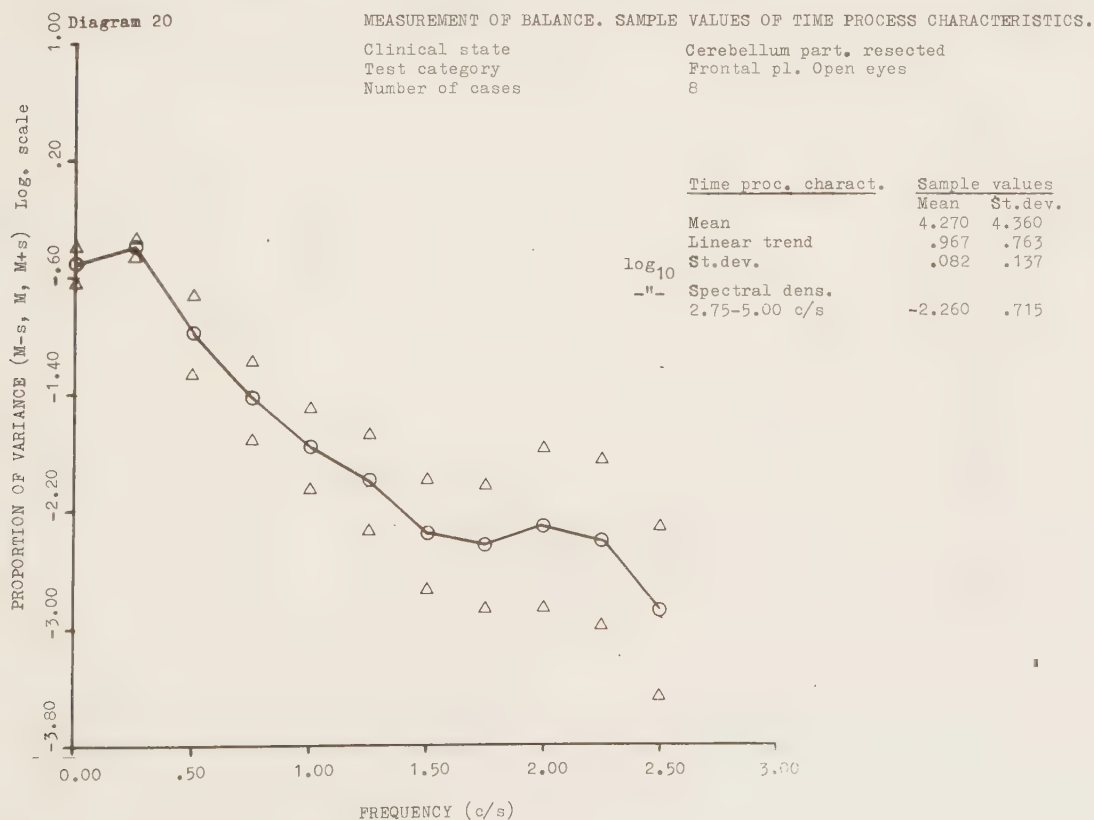
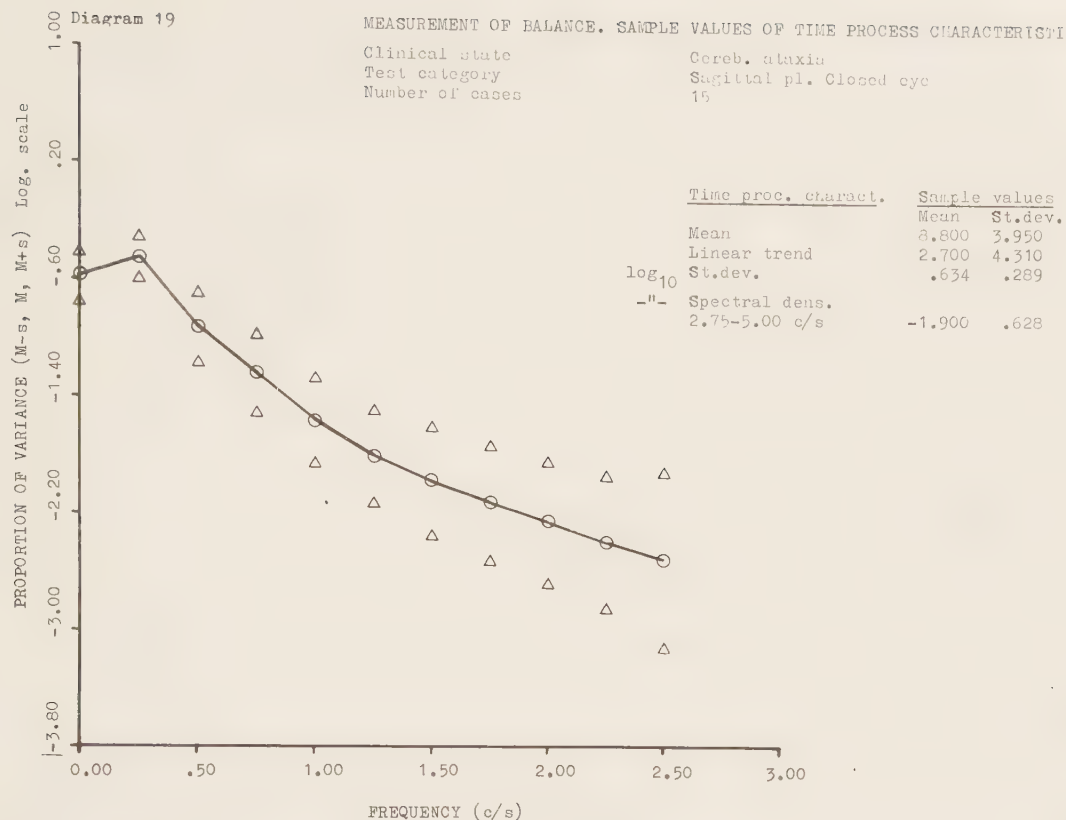


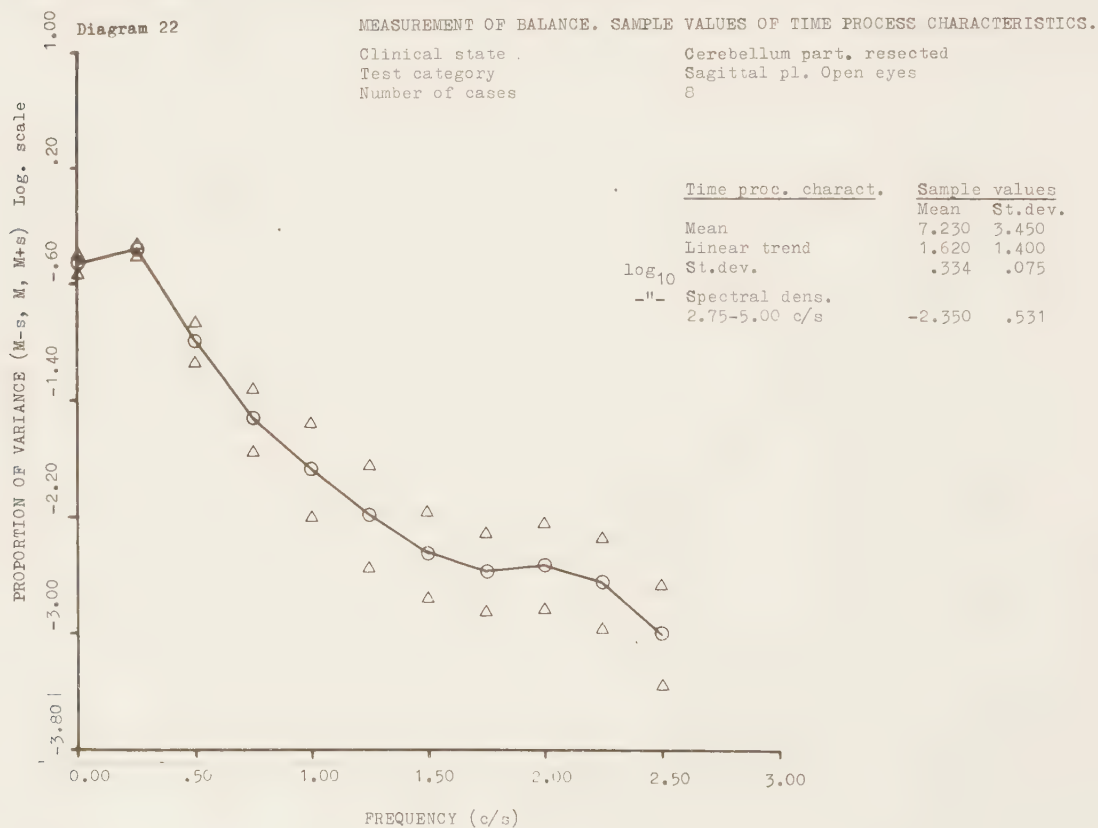
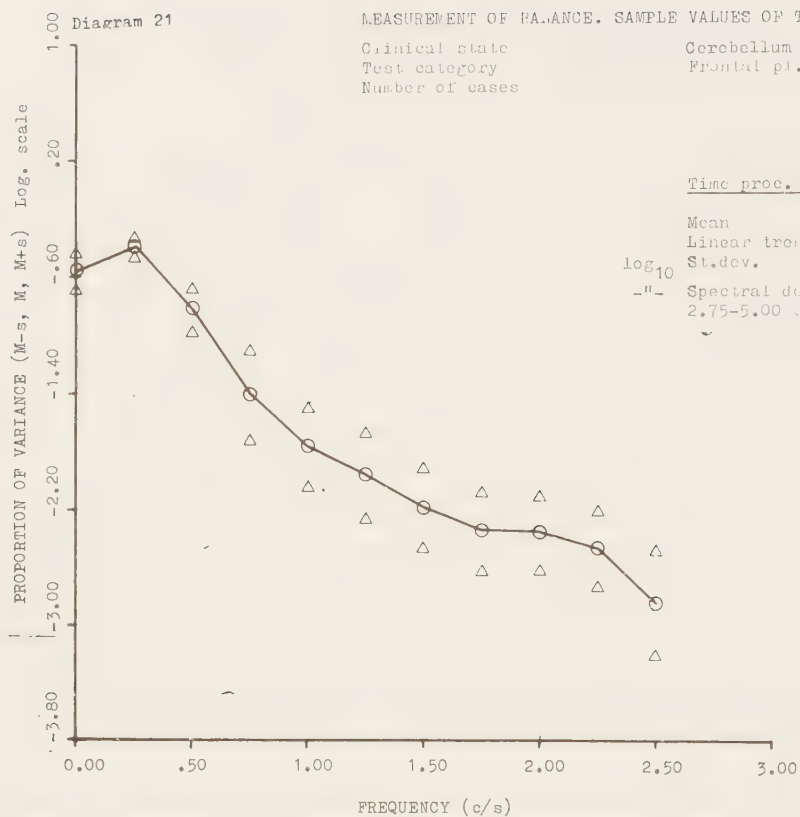


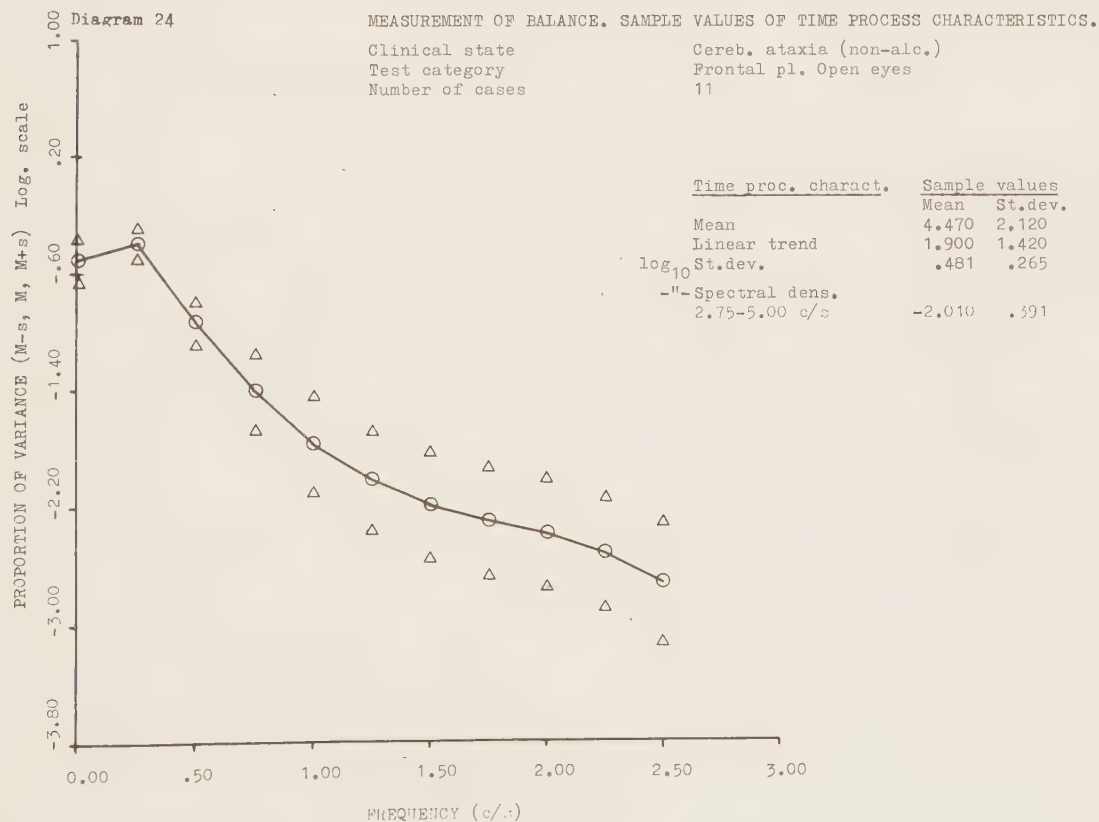
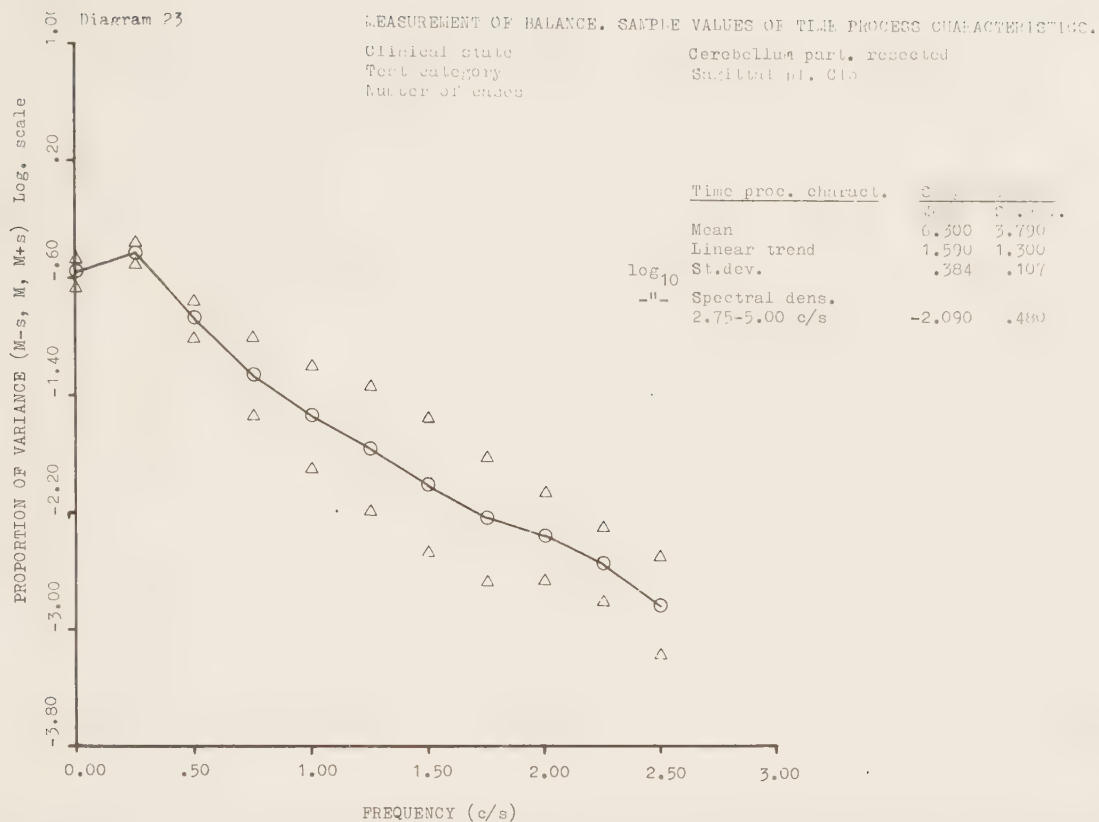


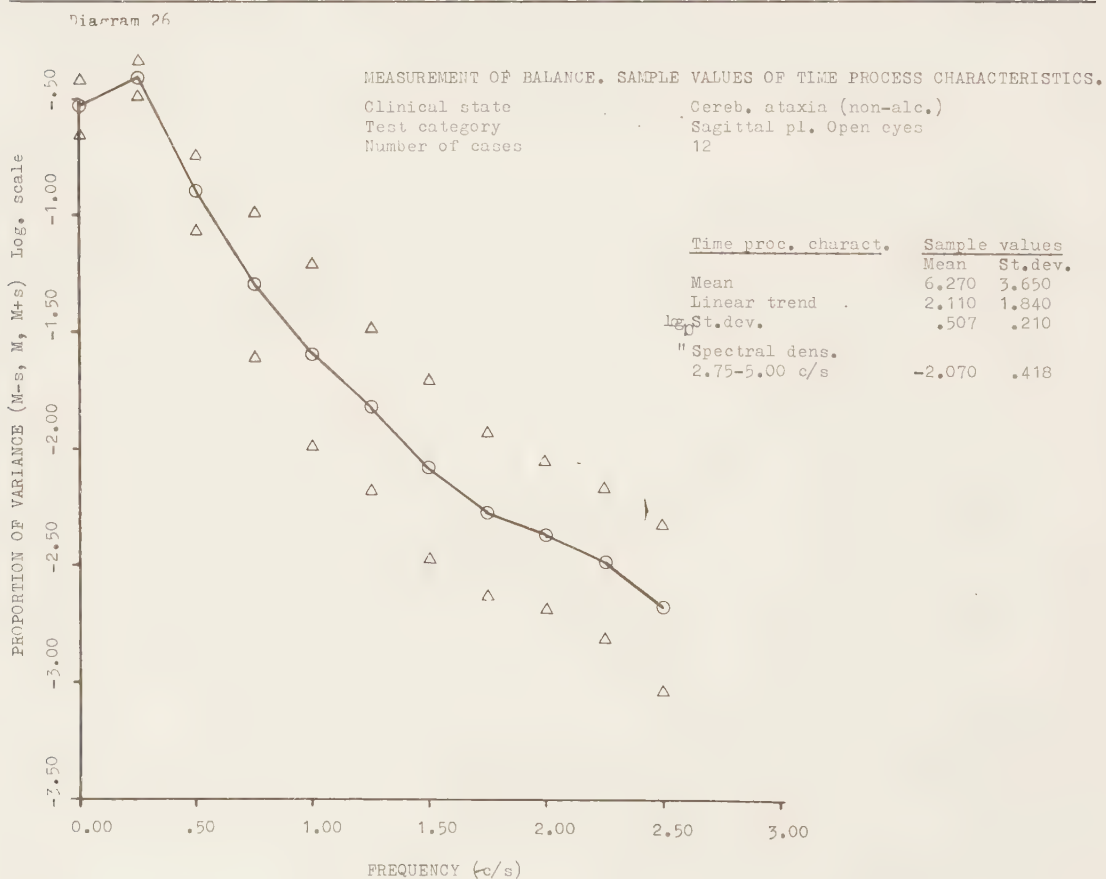
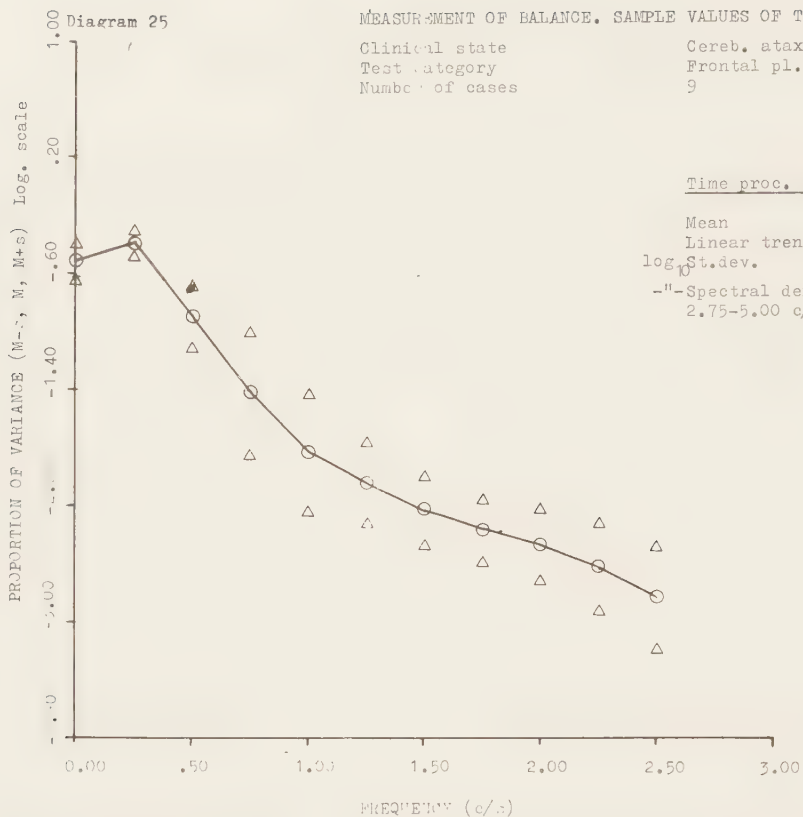


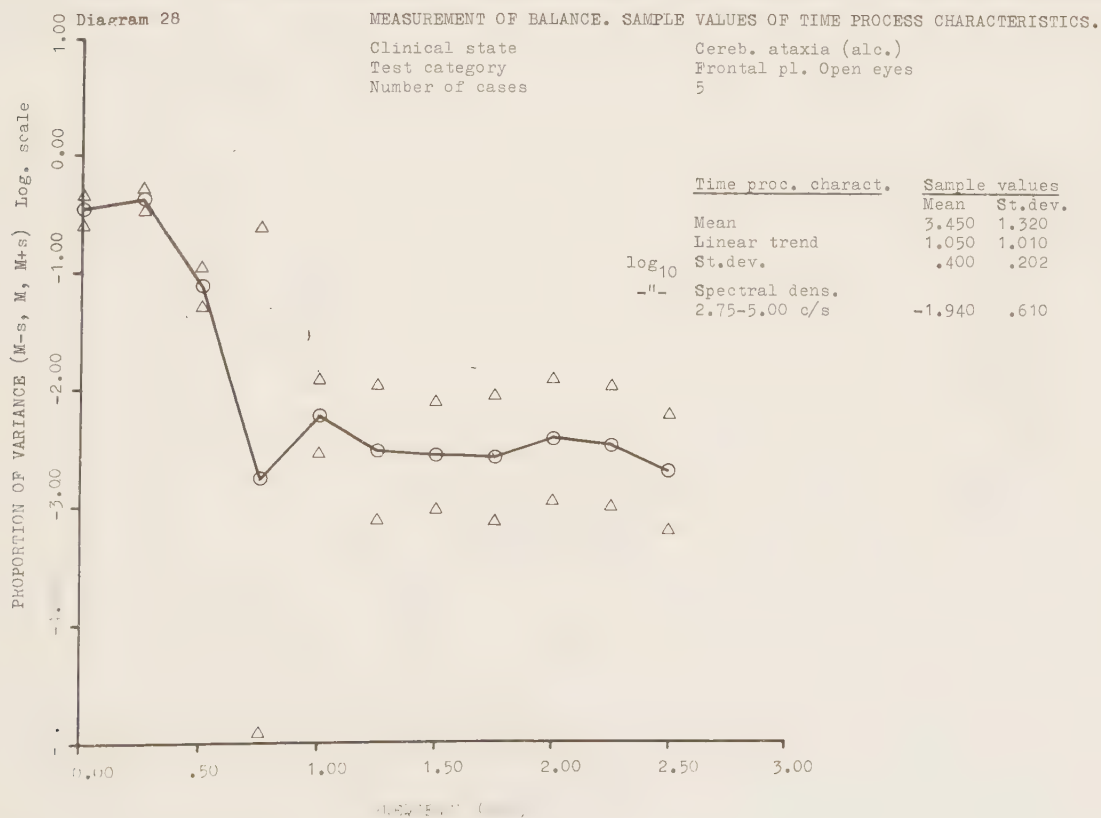
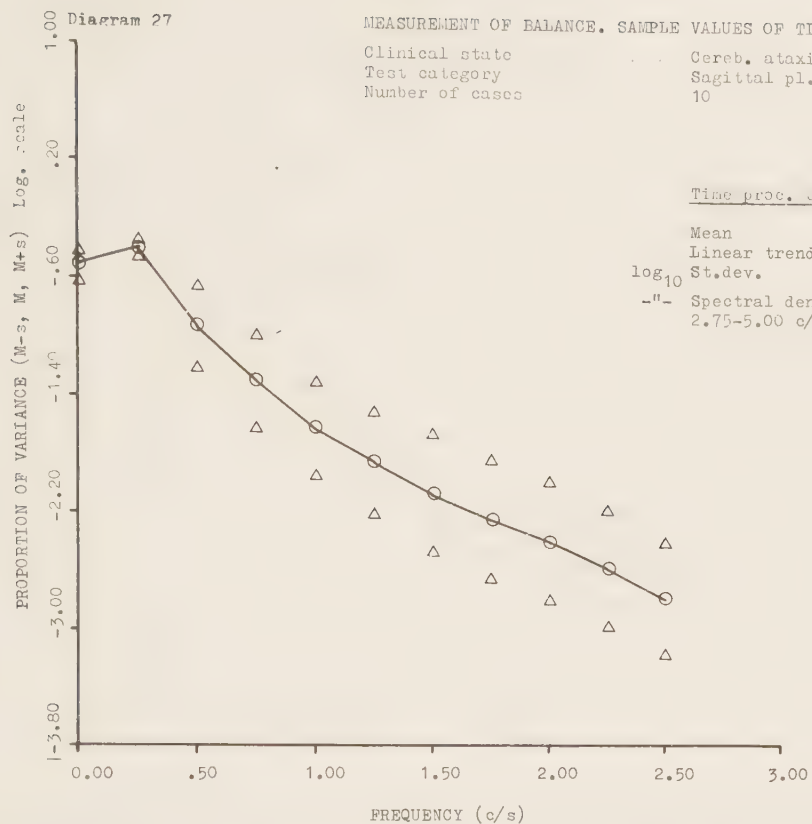


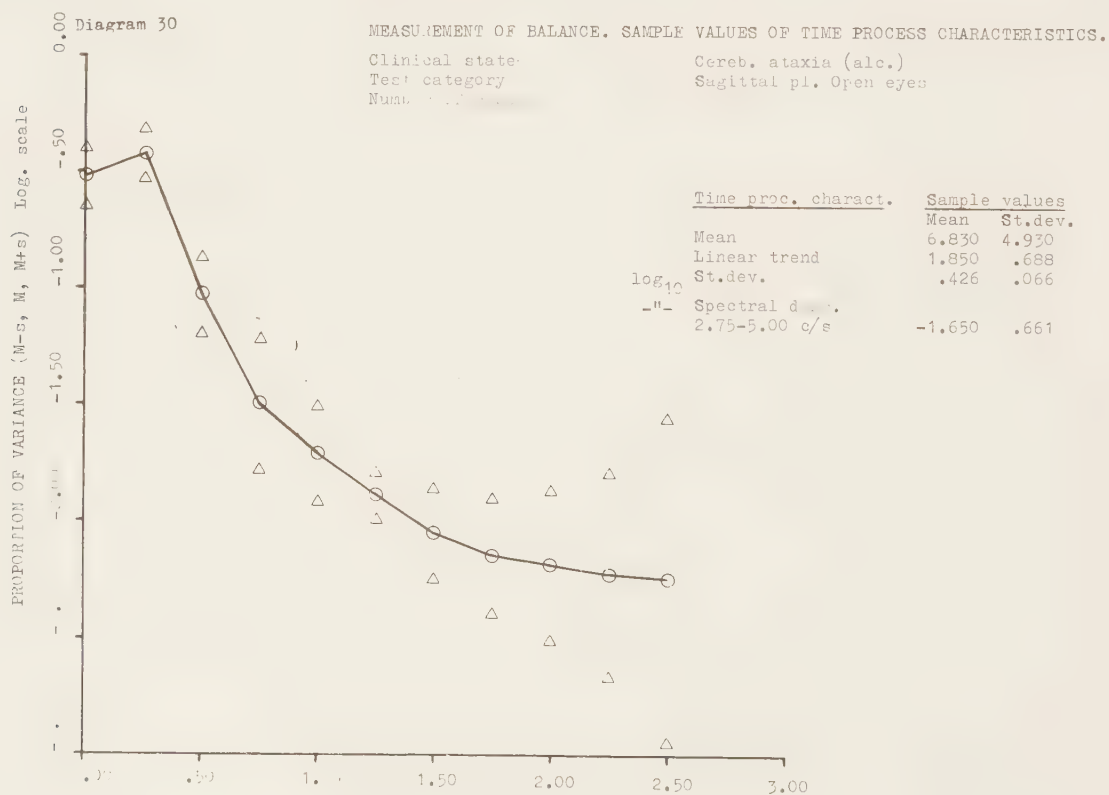
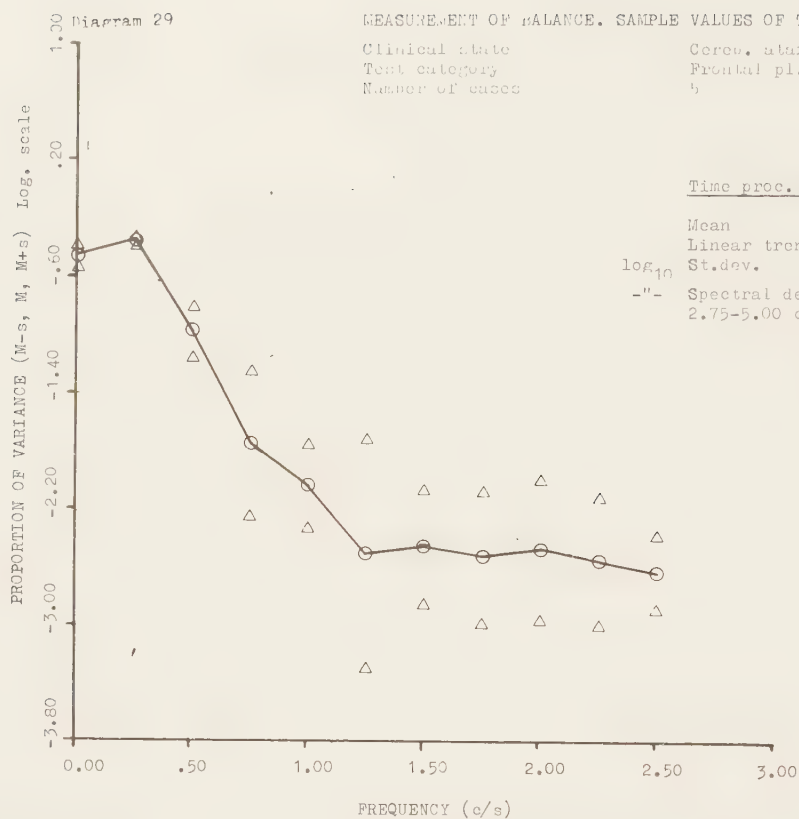


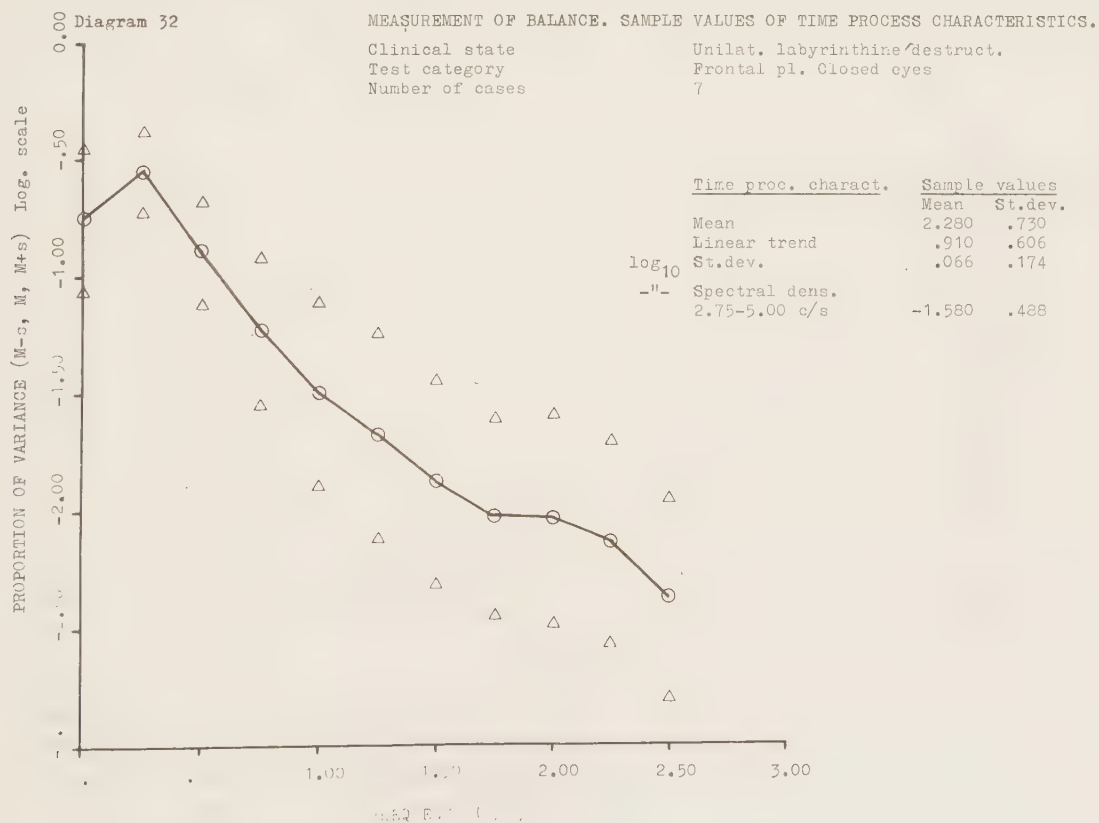
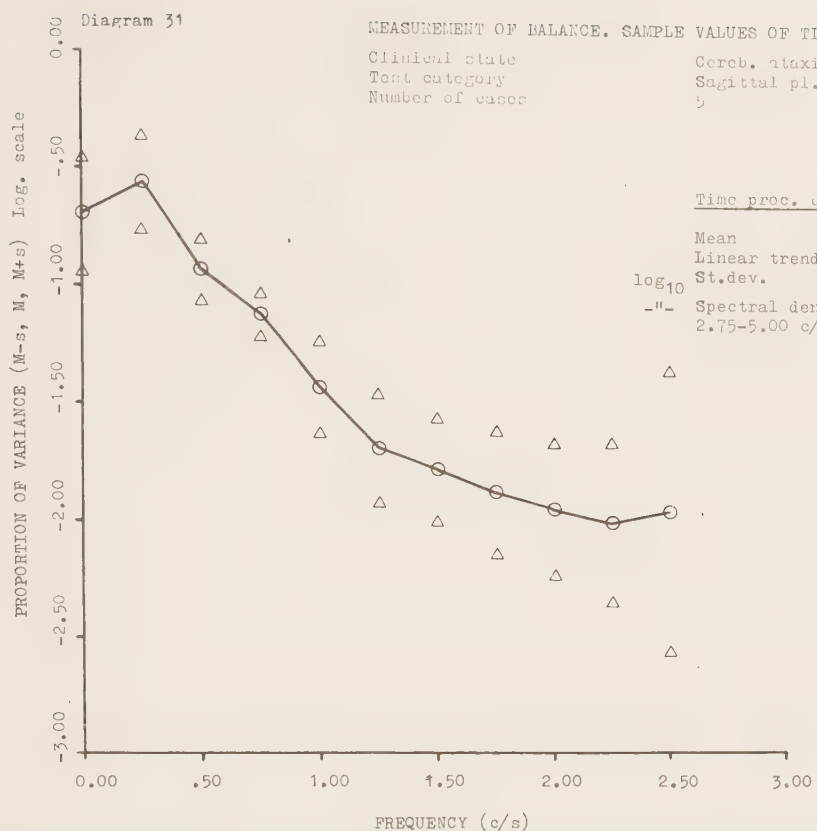


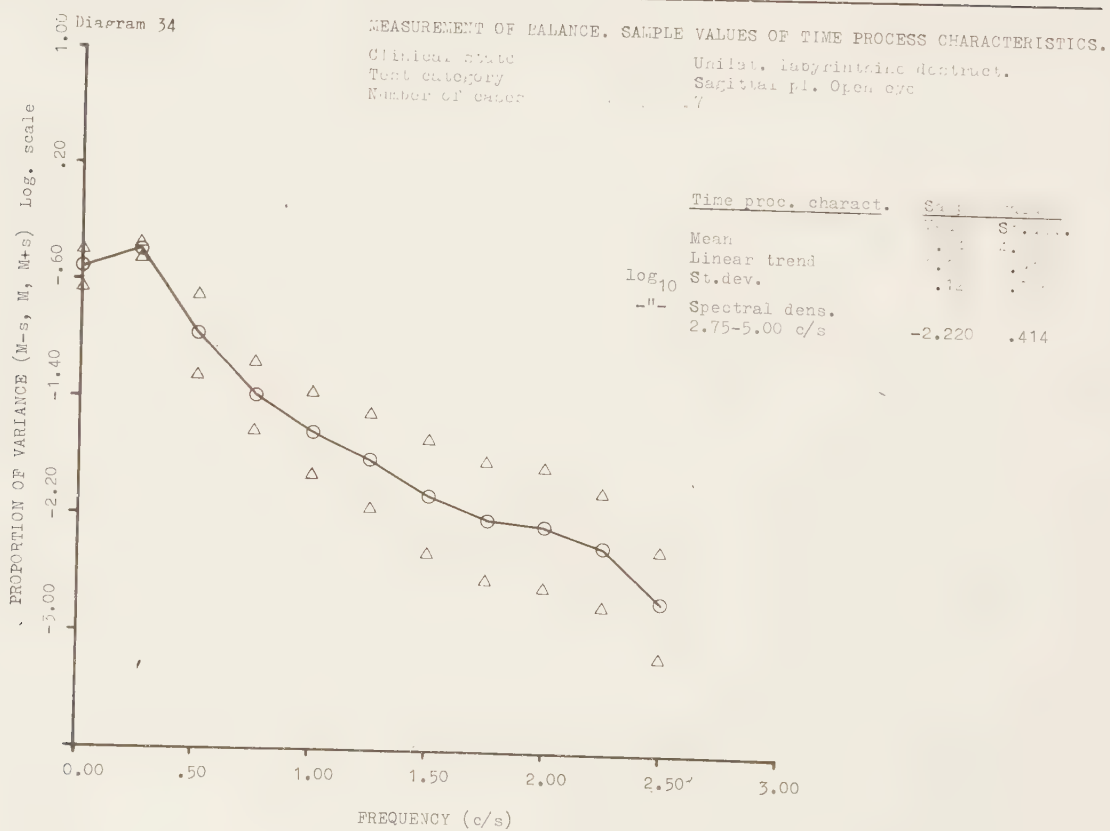
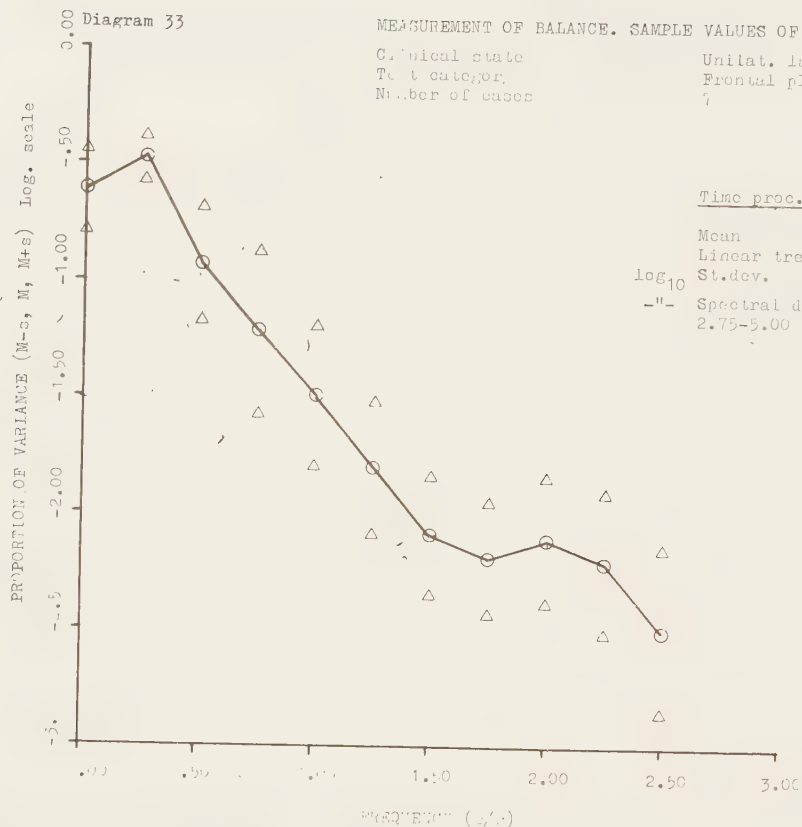


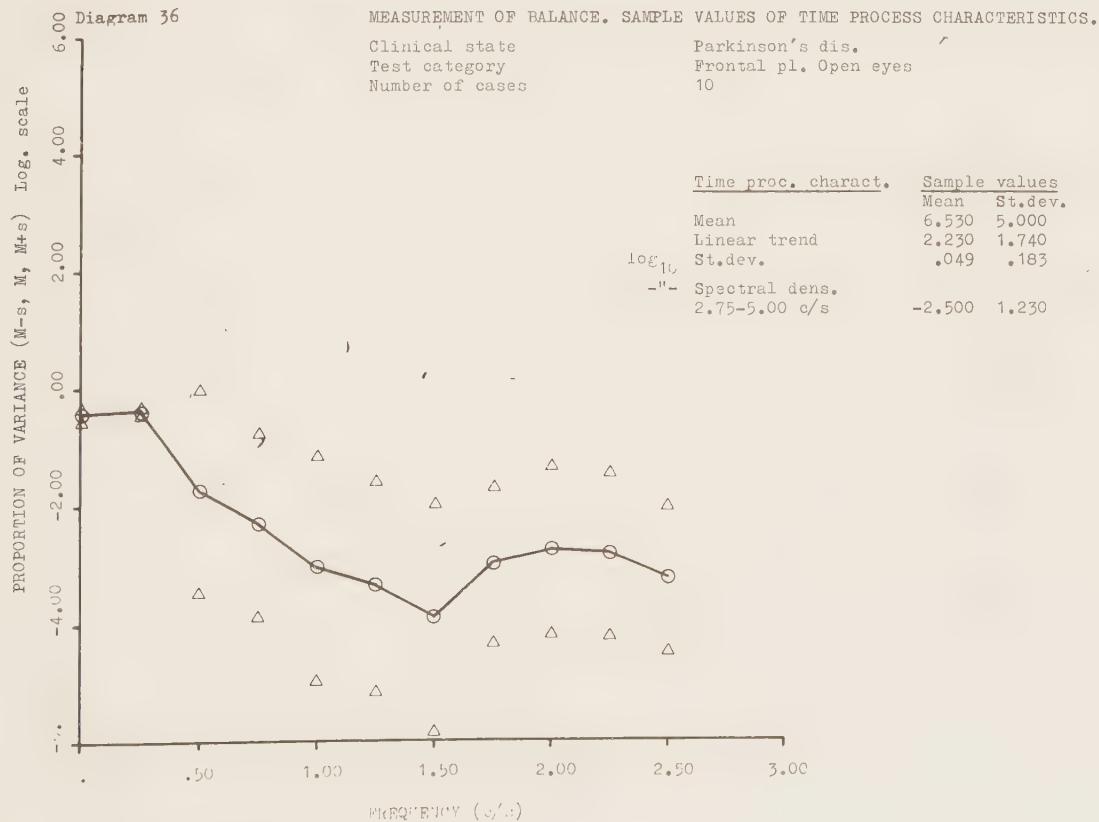
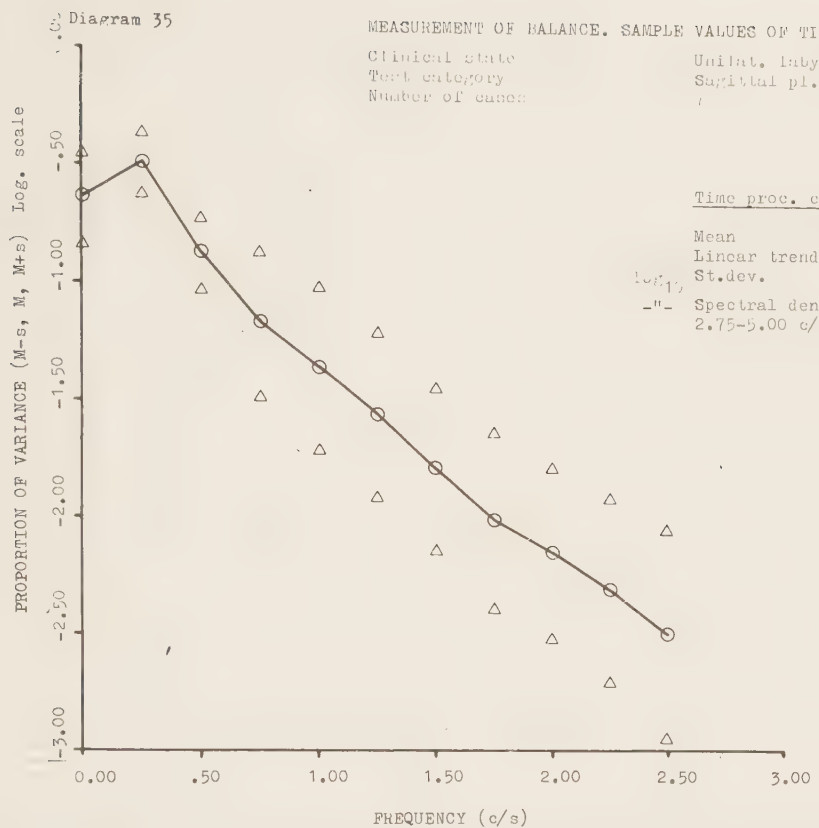


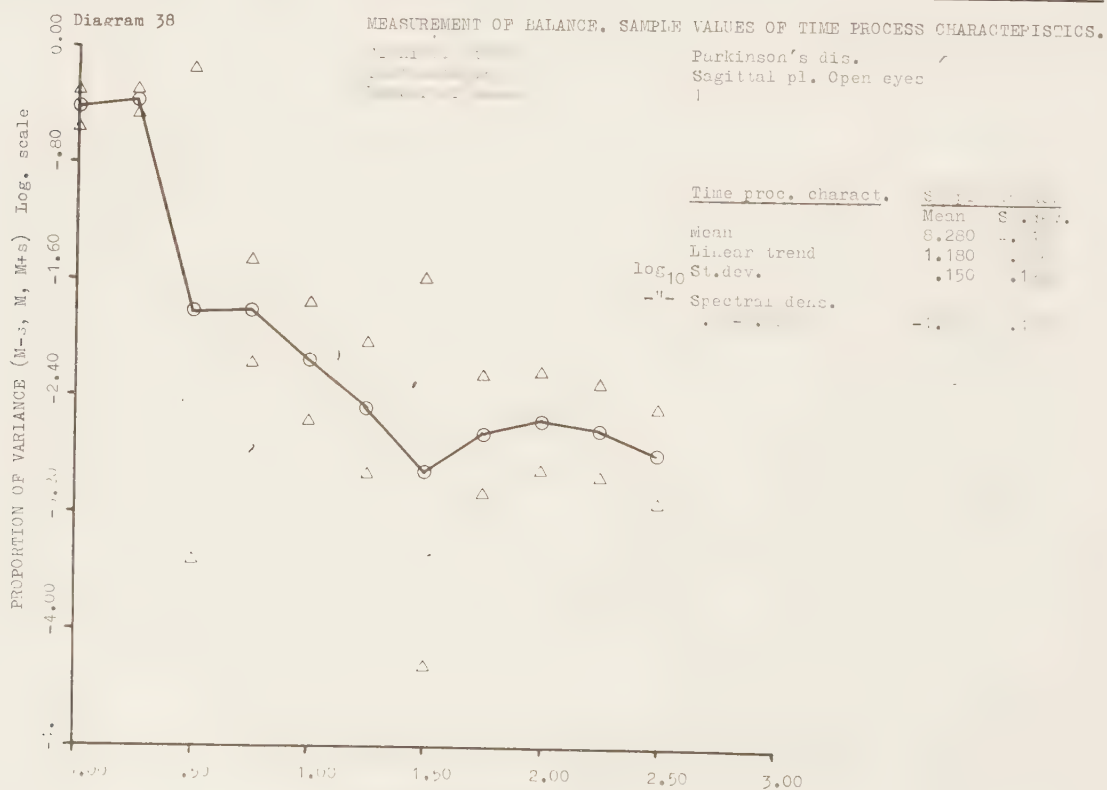
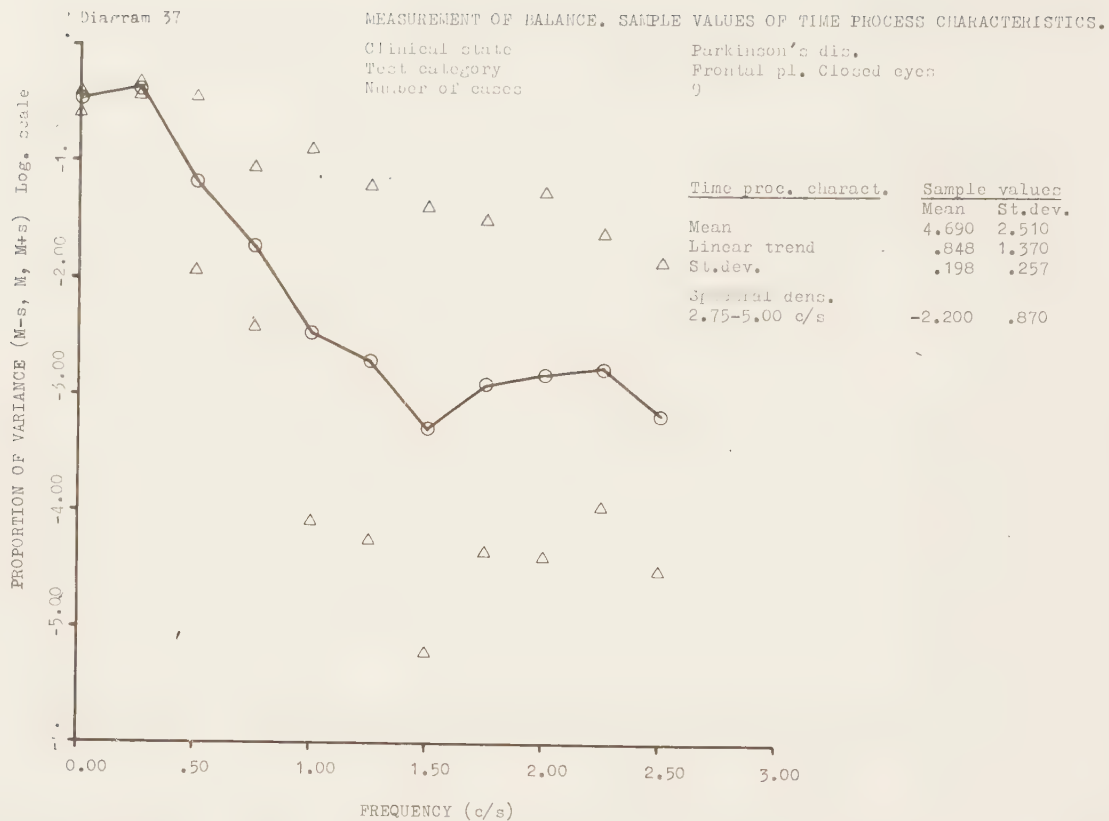


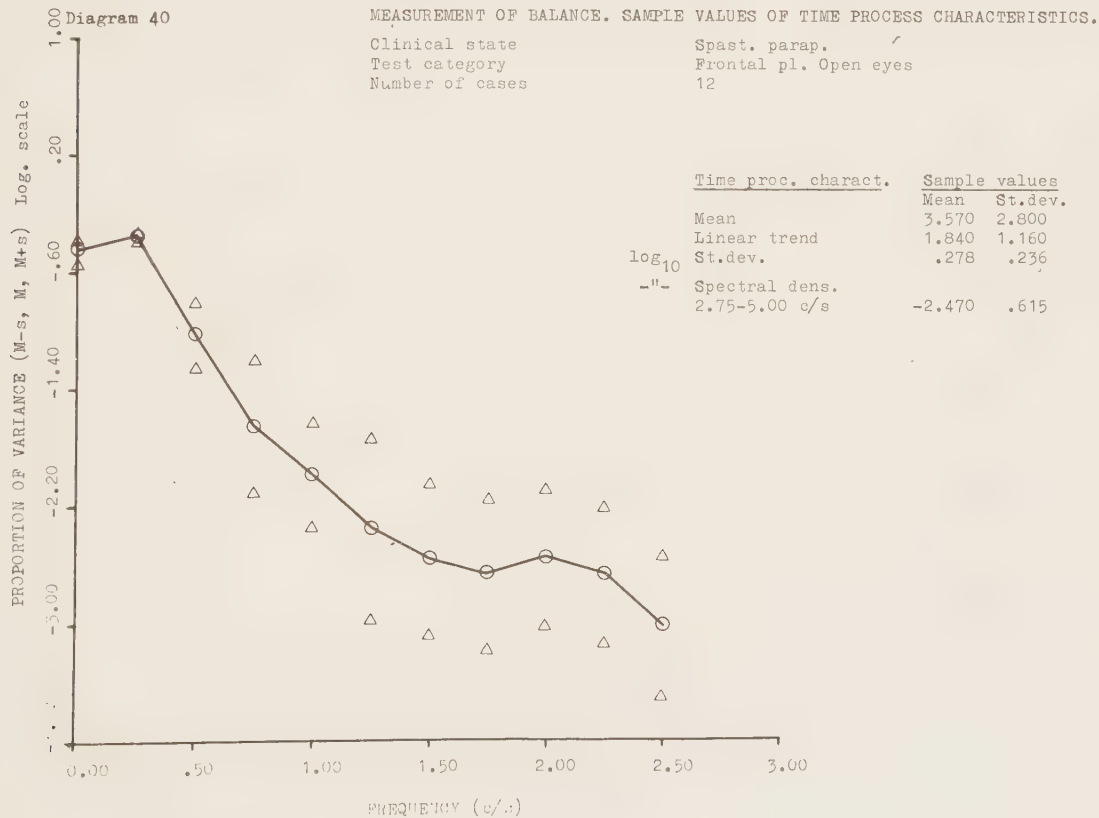
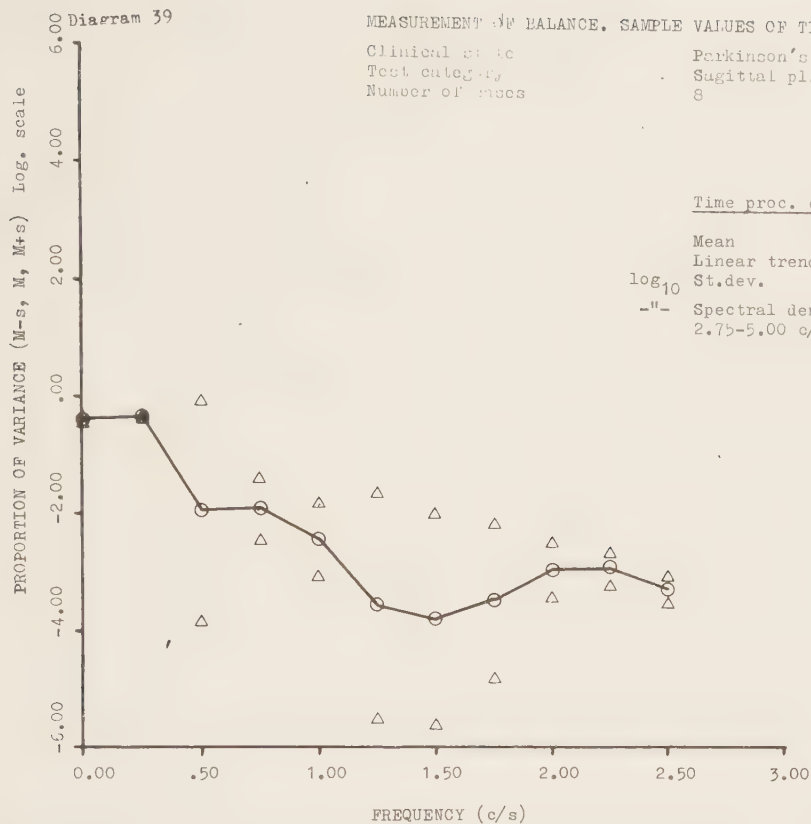


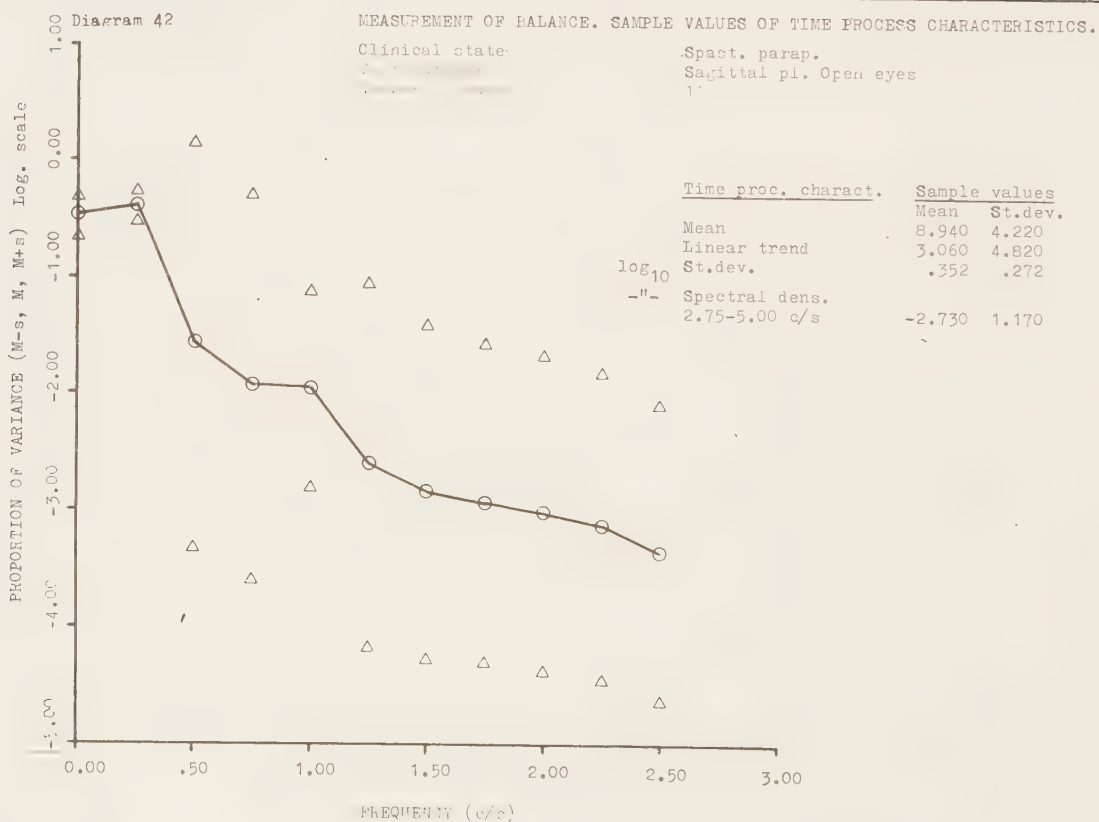
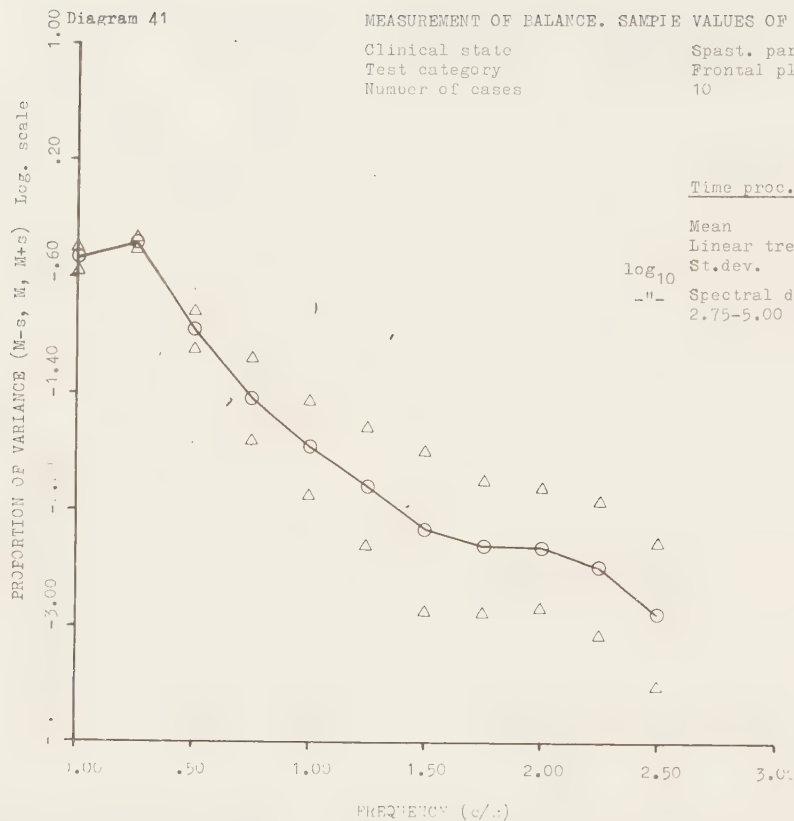


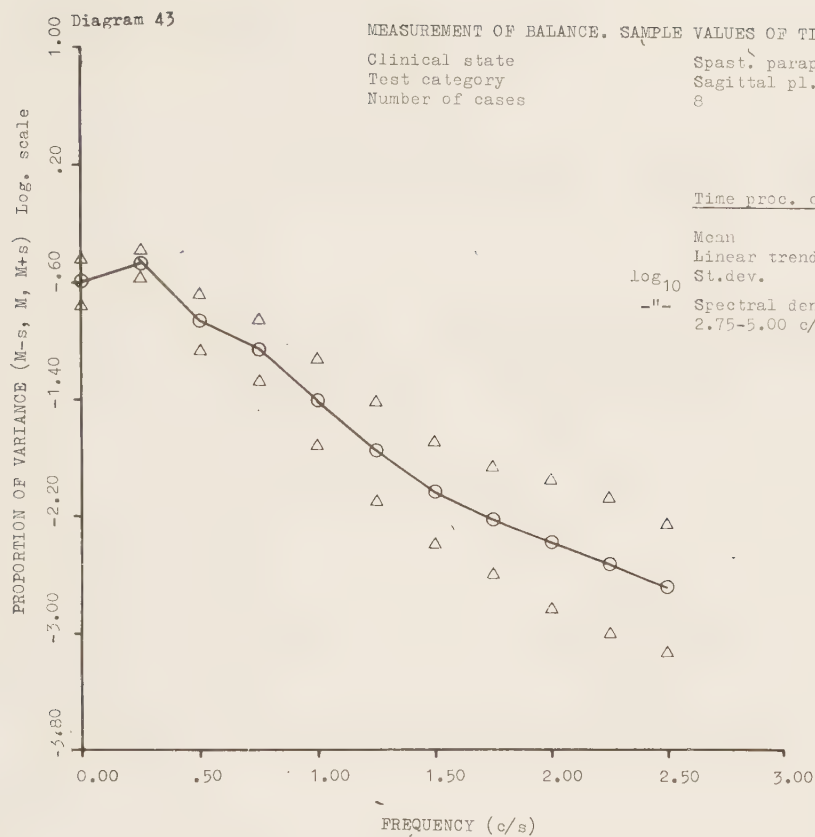












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